REMEDIAL DESIGN REPORT

ESSO TUTU SERVICE STATION
Tutu Wells NPL Site
St. Thomas, U.S.V.I.

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SECTION 1.0

INTRODUCTION

Pursuant to Section III of the Statement of Work (Appendix II) attached to the Unilateral Administrative Order (UAO) dated May 1998, this document is being submitted to fulfill the requirement to prepare a Final Design Report for Work Element I - Soil Remediation and Work Element II - Ground-water Remediation.

The Tutu area of Saint Thomas has been the focus of an ongoing Environmental Protection Agency (EPA) directed investigation subsequent to July 1987. EPA's investigative activities were precipitated as a result of the detection of volatile organic compounds (VOCs) in several potable wells located within the northern portion of the Tutu aquifer Basin. Specifically, sampling conducted by Weston in July 1987, on behalf of EPA, identified the presence of synthetic chlorinated organic compounds and aromatic hydrocarbons at variable concentrations and in sporadic locations within a number of ground-water production wells in the Tutu area. Subsequent to July 1987, periodic water quality sampling of potable wells has been conducted by EPA. Additional site inspections, document reviews, and sampling activities have been implemented in an attempt to identify potentially responsible parties (PRPs).

In 1992 EPA directed the Tutu Environmental Investigation Committee (TEIC), comprised of Texaco Caribbean, Inc. and Esso Standard Oil, to implement a joint hydrogeologic investigation within the Tutu area. In an attempt to characterize the extent and sources of ground-water contamination, monitoring wells were installed, soil/ground-water samples were collected, and aquifer hydraulic information obtained. Findings from this investigation were presented by Geraghty & Miller in a Technical Memorandum (Tech Memo II) dated May 1993. This investigation program represented the first step in the iterative process through which a comprehensive Remedial Investigation/Feasibility study (RI/FS) for the Tutu area was developed.

To address data gaps identified in the Tech Memo II, Geraghty and Miller developed a Phase II RI program in 1993. This program was submitted to EPA in December 1993, and subsequently approved and implemented in 1994. Findings of the Phase II RI were presented in a Phase II RI Report dated April 1995.

In addition to the valley-wide RI activities conducted by EPA and TEIC, several PRPs have conducted site-specific investigations. Specifically, Esso commissioned several site investigations of the Tutu service station which were implemented in a phased-approach and included the following significant tasks:

- assessment of soil quality proximal to former gasoline storage tanks;
- determination of environmental conditions adjacent to potential on-site sources area including the gasoline dispenser island, former location of hydraulic lifts, oil/water separators, and existing gasoline storage tank field.;
- characterization of hydrogeologic conditions beneath and adjacent to the site; and
- determination of ground-water quality on site, as well as upgradient and downgradient of the service station.

EPA issued a Record of Decision (ROD) dated August 5, 1996 which set forth EPA's selected remedy. The major components of the selected remedy as it relates to the Esso service station include the following two Remedial Work Elements:

Remedial Work Element I - Soil Remediation

- Institutional controls to place limitations on property usage;
- Institutional controls to ensure excavation or disturbance of soils will not occur without permit approval, proper worker-protection precautions, and monitoring for fugitive emissions;

- Institutional controls to prohibit excavation, transportation and use of soil or rock from impacted areas with EPA and DPNR approval;
- Soil Vapor Extraction (SVE) treatment and bioventing of impacted soil; and
- Thermal oxidation for off-gas treatment

Remedial Work Element II - Ground-water Remediation

Implement Source Control Program (SCP) including the installation and operation of extraction wells and an air stripper to address impacted ground water.

In accordance with the ROD, a Remedial Design Investigation was implemented to:

- Delineate the extent of impact to vadose zone soils adjacent to the north oil/water separator and dispenser island;
- Define the extent of the perched water zone and the phase-separated hydrocarbons in the vicinity of the north oil/water separator;
- Quantify site-specific vadose zone characteristics to establish soil cleanup criteria; and
- Collect requisite data to design a soil vapor extraction and ground-water collection remediation system.

Field investigation activities were performed during the period from September 16, 1996 to October 16, 1996. Based upon the investigative information collected during the Remedial Design Investigation, a Source Control Program was developed. The objectives of the Source Control Program are as follows:

- Remove phase-separated hydrocarbons present in the perched water zone on site and the shallow portion of the bedrock aquifer both on site and off site;
- Remediate vadose zone soils to ensure potential leaching of contaminants from unsaturated soil to the water table does not result in ground-water concentrations above Federal Maximum Contaminant Levels (MCLs); and
- Hydraulically capture and remediate volatile aromatic hydrocarbon plume present in the overburden and shallow bedrock.

The investigation findings and a conceptual design for the components of the Source Control Program were presented in the Remedial Design Investigation/Source Control Program Report (FES, 1997). The remedial system will involve the following:

- Oil vapor extraction (SVE) and bioventing of vadose zone soils;
- Removal of phase-separated hydrocarbons using both fluid extraction and vapor extraction/bioventing; and
- Ground-water recovery and treatment with an air stripper.

This document is being submitted in fulfillment of the requirement for submission of the Final Design Report for Remedial Work Elements I and II. The report is organized as discussed below, along with supporting appendices. Section 2 summarizes the site environmental setting data and background information relative to the extent of soil and ground-water contamination. Section 3 discusses institutional controls. Section 4 discusses design criteria for Work Elements I and II. Section 5 presents the performance criteria and contingency measures for Work Elements I and II. Section 6 is the Sampling, Analysis, and Monitoring Plan. Section 7 address operations and maintenance. Finally, Section 8 is the Construction Quality Assurance Project Plan and Section 9 the schedule.

SECTION 2.0

SUMMARY OF SITE ENVIRONMENTAL CONDITIONS

2.1 Site Geology and Hydrogeology

The geologic sequence at the Esso Tutu Service Station consists of fill and unconsolidated Quaternary sediments overlying volcanic rock. The fill material varies in thickness from 2 to 3 feet at the northern property boundary to approximately 10 to 15 feet in the southwestern portion of the site. In general, the fill consists of a fine sand/silt/clay matrix surrounding angular rock fragments. In certain areas, such as the southwestern corner of the site, the fill material also includes cobbles and construction debris. Beneath the fill are unconsolidated alluvial and colluvial deposits and weathered bedrock. These sediments range in thickness from 2 feet in the northern portion of the site to approximately 5 to 6 feet in the southwestern corner of the property. These deposits can best be characterized as a poorly sorted mixture of clay, silt, sand, gravel and cobbles. Weathered bedrock (saprolite) at the site is composed of dense silt and clay, extending from depths ranging from 4 feet to 20 feet below the ground surface.

The bedrock in the vicinity of the Esso Tutu Service Station consists of two volcanic formations: the Water Island Formation; and the Louisenhoj Formation. The Water Island Formation is composed primarily of basaltic flows and breccias. It is unconformably overlain by the Louisenhoj Formation which consists of pyroclastic to epiblastic augite andesite tuffs and breccias. Locally, the base of the Louisenhoj Formation consists of the Cabes Point Conglomerate, which contains well rounded and well sorted pebbles and cobbles or the older Water Island Formation (Donnelly 1959 and 1966). The depth to competent bedrock varies from 5 feet along the northern property boundary to 20 feet in the southwestern portion of the site.

Ground water at the Esso Tutu Service Station is present in two separate units: a shallow perched water zone and the regional water table aquifer. A localized perched ground-water zone is present in the southwestern portion of the station property, proximal to the north oil/water separator (Figure 2-1). Perched ground-water conditions are manifested as a result of a permeability gradient between fill deposits and saprolite strata. The increased clay content and limited permeability of saprolite strata inhibits the vertical transport through the vadose zone. Perched water conditions were not encountered during soil boring advancement north of the north oil/water separator or in the area of the dispenser island/USTs. Similarly, perched water conditions were not encountered at monitoring well SW-8 or the MW-9 cluster, effectively defining the spatial extent of the perched ground water beneath the site. Depth to water in the perched zone is approximately 9 feet to 10 feet below grade.

Considering both the limited spatial extent of the perched water zone and the site lithology, horizontal ground-water migration in this unit is thought to be minimal. Ground-water elevation data suggest that there is little, if any, hydraulic interaction with the underlying water table aquifer. Information collected during ground-water pumping tests, as well as ground-water monitoring events, demonstrate that water levels in the two units fluctuate independently. Historically, ground-water elevations in the perched zone have been consistently 8 feet to 10 feet higher in elevation than water levels in the water table aquifer.

The source of hydraulic recharge, if any, to the perched zone has not been specifically identified. The presence of pavement and above ground structures both on and proximal to the site, reduce the potential for surface water/precipitation infiltration. Observations recorded during the completion of soil borings and trenches north of the oil/water separator and/or dispenser island demonstrated the absence of moisture in subsurface deposits, despite the termination of borings/trenches upon the bedrock surface. One potential recharge source may be the cistern located beneath the station building. The cistern had received water from the roof drainage system prior to the impact of Hurricane Marilyn (Fall 1995). Subsequently, the cistern has been replenished with shipments of water delivered once or twice per week (water from the cistern is presently used in the station rest rooms).

Ground water associated with the water table aquifer is present at depths of 17 to 20 feet beneath the site. Although chemical properties of the water table aquifer vary with depth, shallow and deep portions of the aquifer a believed to comprise a single hydrogeologic unit. Regional ground-water flow beneath the site is generally north to south, under an approximate hydraulic gradient of 0.03 (Figure 2-2). Vertical ground-water elevation measurements suggest a slight downward gradient ranging from 0.0035 to 0.01.

Aquifer characteristics have been quantified through a series of single-well hydraulic conductivity tests (i.e., slug tests) and short term constant rate pumping tests. Single-well hydraulic conductivity tests indicate that the permeability of the shallow fractured bedrock beneath the Esso Tutu Service Station ranges from 4.61×10^{-6} ft/min to 1.55×10^{-4} ft/min. Calculated hydraulic conductivity values for the deeper portion of the fractured bedrock (well location DW-1) was 1.01×10^{-5} ft/min. Ground-water pumping tests, conducted at a rate of 0.5 gpm in wells SW-1, SW-3, SW-7 and CHT-2, demonstrated hydraulic conductivity values ranging from 4.0×10^{-6} ft/min to 1.3×10^{-3} ft/min. Most calculated hydraulic conductivities were within the range of 10^{-4} ft/min to 10^{-5} ft/min. All of the bedrock wells used during pumping test activities could not sustain an extraction rate of 0.5 gpm for a period greater than 2 hours. The low permeability of the shallow fractured bedrock is demonstrative of the limited fracture density proximal to the service station site.

Hydraulic conductivity data for the aquifer pumping tests, in conjunction with ground-water gradient information, indicate that ground-water velocity in the area of the Esso Tutu Service Station is relatively slow. Employing the geometric mean of the hydraulic conductivity data (0.0001 ft/min) for the shallow aquifer monitoring wells, and assuming an effective porosity of 0.15 for the shallow bedrock zone, produces a calculated ground-water velocity of approximately 10.5 feet per year.

2.2 Contaminants of Concern

As defined in the August 5, 1996 Record of Decision (ROD), specific contaminants of concern for the entire Tutu Wells NPL Site include volatile aromatic hydrocarbons (benzene, toluene, ethylbenzene, xylene) and chlorinated volatile organic compounds (CVOCs) including tetrachloroethene, trichloroethene, dichloroethene, and vinyl chloride.

2.3 Extent of Soil Impact (Remedial Work Element I)

Two areas within the unconsolidated vadose zone soils at the Esso Tutu Service Station have been identified as being impacted: 1) the area surrounding and downgradient (i.e., south) of the north oil/water separator; and, 2) the former dispenser island and product distribution lines.

2.3.1 North Oil/Water Separator

Soil quality proximal to the north oil/water separator was defined during previous sampling programs implemented in 1993 and 1996. Samples SS-1, SS-3, SS-4, SS-5, SS-6, SS-7, and SS-8 were collected on the western side of the separator following excavation and removal of the effluent pipe in 1993 (Figure 2-3). Ten soil borings were drilled proximal to the north oil/water separator in 1996 to: 1) delineate the extent of impact north of the separator; and 2) characterize the contaminant levels associated with the perched water conditions south of the separator (proximal to well SW-7). Borings B-16 and B-17 were installed north of the separator and borings B-1, B-2, B-5, B-6, B-7, B-15, B-18, B-19, and B-20 were drilled south of the separator (Figure 2-4).

Analytical data from these sampling events detected the presence of aromatic hydrocarbons (e.g., BTEX), polynuclear aromatic hydrocarbons (PAHs), and to a lesser extent CVOCs. CVOCs were detected only in soil samples collected from a test pit to the west of the separator in 1993. No CVOCs were detected in soil boring samples collected in 1996. CVOCs are limited to the shallow soils adjacent to the north oil/water separator, they were not widespread in the perched water zone. The following discussion summarizes the conclusions regarding the distribution of these different compounds presented in the Remedial Design Investigation/Source Control Program Report (FES, 1997).

Aromatic hydrocarbon compounds, present in the vicinity of the north oil/water separator and the alleyway to the south of the separator, were detected at the highest concentrations in soil samples SS-1 (9 feet), SS-3 (3 feet), SS-7 (5 feet) and SS-8 (7 feet), all collected from a test pit located immediately west of the separator (Table 2-1). Compounds detected at the highest concentration included toluene, ethylbenzene, and xylenes, with a maximum reported total BTEX concentration of 142.3 mg/kg. Samples SS-4 and SS-5, collected about 8 feet west of the separator, contained total BTEX levels of 29.8 and 36.0 mg/kg, respectively. Aromatic hydrocarbons were not detected in Sample SS-6, located about 12 feet west of the separator and adjacent to the western property boundary, effectively delineated the western extent of aromatic impact. Samples collected from south of the separator (B-5, B-6, B-7, B-15, and B-20) demonstrated low concentrations of total aromatic hydrocarbons (less than 1 mg/kg), delineating the southern extent of soil impact (Table 2-2). Borings B-16 and B-17 effectively delineate the extent of aromatic compounds north of the separator.

CVOCs were observed in the soil samples collected from the test pit immediately to the west of the north oil/water separator, except for sample SS-6. Compounds detected including 1,2-dichloroethene (1,2 DCE), trichloroethene (TCE), tetrachloroethene (PCE), and 1,1,1-trichloroethane (1,1,1-TCA) (Table 2-2). Samples SS-3, SS-7, and SS-8 exhibited the highest

CVOC concentrations with total CVOC concentrations of 5.12 mg/kg, 0.67 mg/kg, and 2.19 mg/kg, respectively. Individual compounds observed at the highest concentrations included 1,2 DCE (3.2 mg/kg, sample SS-3) and PCE (1.5 mg/kg, sample SS-8). Chlorinated volatile compounds were not detected in any of the 25 samples analyze for CVOCs during the 1996 RD Investigation.

The presence and distribution of PAH compounds mimicked that of the aromatic compounds. In general, the highest levels were reported adjacent to the north oil/water separator at depths of 3 to 7 feet (samples SS-3, SS-7, and SS-8). Individual constituents detected at the highest concentrations included naphthalene, phenanthrene, and pyrene. Sample SS-6 collected along the western property boundary demonstrated non-detectable levels of all PAHs. Although PAH compounds were observed in soil samples collected in the alleyway south of the separator as well as north of the separator in sample B-16 (Table 2-2), the reported concentrations were less than those observed adjacent to the separator.

In summary, field observations during the drilling of borings south of the north oil/water separator demonstrated the highest concentrations of aromatic hydrocarbon and PAH compounds in the 8 to 10 foot and 10 to 12 foot sample intervals. These sample intervals correlate with the elevation of the perched water zone, and as such contamination in this area has resulted from horizontal transport of hydrocarbons on the perched water.

2.3.2 Dispenser Island and Product Distribution Lines

Soil quality adjacent to the former dispenser island and product distribution lines have been defined through previous sampling and investigative programs implemented in 1993, 1995, and 1996. Soil borings SW-1, SW-2, and SW-3 (Figure 2-4) were drilled and sampled in 1993. Ten soil borings were drilled in 1996; borings B-3, B-4, B-8, B-9, and B-10 were located adjacent to the former dispenser island, while borings B-11, B-12, B-13, B-14, and B-24 were located further west and adjacent to the service station building.

Analytical data obtained during these investigations demonstrated the sporadic presence of BTEX and PAHs compounds. CVOCs were detected in any samples collected adjacent to the dispenser island and product delivery lines. The following discussion summarizes the conclusions regarding the distribution of these compounds presented in the Remedial Design Investigation/Source Control Program Report (FES, 1997).

Aromatic hydrocarbon compounds were detected in samples collected from boring B-3 drilled adjacent to the former pump island as well as borings B-11 and B-13, completed adjacent to the service station building. The maximum total BTEX concentrations in these three borings were 1.1 mg/kg, .002 mg/kg, and .15 mg/kg, respectively. The depth of impact in these borings was typically shallow (4 to 8 feet). BTEX compounds were either not detected or reported at low estimated concentrations in the remaining borings installed adjacent to the former pump island. The highest BTEX concentrations were observed in samples B-14 (47.2 mg/kg, 10 to 12 feet) and B-24 (236.7 mg/kg, 9 to 11 feet) while samples collected at shallower depths in these same borings demonstrated low to non-detectable levels of BTEX compounds. Field observations and these analytical results suggest that the contamination associated with the perched water zone encountered during investigation of the north oil/water separator extends as far eastward as boring B-24 (Figure 2-1).

Samples from borings B-3, B-4, B-14, and B-24 were submitted for PAH analyses. Analytical results for samples from borings B-3 and B-4 were reported at an elevated method detection limit, generally less than 0.1 mg/kg. The distribution of PAH compounds in borings B-14 and B-24 mimics that of the aromatic compounds.

2.4 Extent of Ground-Water Impact (Remedial Work Element II)

Ground-water quality data indicate the presence of two distinct contaminant plumes beneath the subject property: 1) a volatile aromatic hydrocarbon and dissolved PAH plume emanating from the north oil/water separator and, 2) a volatile aromatic hydrocarbon plume originating from the dispenser island/distribution line area. The aromatic hydrocarbon plume originating from the dispenser island area has impacted ground-water quality in the shallow bedrock aquifer. Impact associated with the north oil/water separator is principally limited to the perched ground-water zone. Phase-separated hydrocarbons have been associated with each of the plumes. Although CVOCs were detected in a limited area of shallow soils (e.g., 3 to 7 feet deep) adjacent to western edge of the north oil/water separator, CVOCs have not been detected in water or phase-separated hydrocarbons associated with the perched water zone. CVOCs are present in upgradient well MW-8 and are considered indicative of the regional impact to the Tutu Aquifer from upgradient sources.

2.4.1 North Oil/Water Separator

Data characterizing ground-water quality in the perched water zone and downgradient of the north oil/water separator has been obtained from monitoring well SW-7 (Figure 2-4). Ground-water elevation data for well SW-7 indicates this well is screened within the perched water zone and hydraulically separated from the water table aquifer. As depicted in Figure 2-1, the spatial extent of the perched zone is limited. The perched zone was not encountered during the drilling of wells SW-3, SW-8, or CHT-2.

Ground-water quality monitoring at well SW-7 over a 2.5 year period demonstrated concentrations of individual BTEX analytes ranging from a minimum of 16 µg/L (toluene) to a maximum of 171 µg/L (total xylenes) (Table 2-3). Two sampling events in 1994 demonstrated benzene concentrations of 160 µg/L and 99 µg/L.

Certain PAH compounds have also been observed in ground-water samples collected from well SW-7, including naphthalene, fluorene, and phenanthrene. Individual concentrations of PAH compounds have ranged from not detected to 96 µg/L (naphthalene). Chlorinated volatile organic compounds have never been detected in ground-water samples from well SW-7. The detection of PAH and aromatic compounds in well SW-7 is indicative of a release from the north oil/water separator and consistent with the compounds observed in soil samples collected following removal of the effluent pipe from the separator.

2.4.2 Dispenser Island and Product Distribution Lines

Monitoring wells characterizing ground-water quality proximal to the dispenser island, distribution lines, and USTs include SW-1, SW-2, SW-3, and CHT-3 (Figure 2-4). Monitoring wells MW-8, SW-8, CHT-7D, MW-10, and MW-10D are instrumental in defining the spatial extent of the aromatic hydrocarbon plume emanating from the gasoline storage and dispensing area.

Ground-water quality data from wells SW-1, SW-2, and SW-3 have consistently demonstrated the presence of aromatic compounds. The highest reported concentrations were observed at wells SW-1 and SW-3, with total BTEX concentrations ranging from approximately 55 mg/L to 135 mg/L, respectively. Phase-separated gasoline was detected in well SW-3 during the 1996 sampling program. Although BTEX constituents were detected in SW-2, reported concentrations were significantly less than those observed in SW-1 and SW-3. During the September 1996 sampling event, individual BTEX compounds at SW-2 ranged from a minimum of 18 µg/L (ethylbenzene) to a maximum of 220 µg/L (benzene). Data from well SW-2 during the 1994 sampling events demonstrated slightly higher concentrations, however, total BTEX levels were still less than 8 mg/L.

Aromatic hydrocarbon compounds (i.e., BTEX analytes) have consistently been detected in well CHT-3, located approximately 20 feet downgradient of the USTs. Data from 1994 indicated total BTEX concentrations of approximately 4.5 mg/L, while observations recorded in

1996 indicated the presence of phase-separated gasoline. Monitoring well MW-10, located approximately 50 feet downgradient of the USTs demonstrated the presence of benzene (2 µg/L, estimated concentration) and ethylbenzene (5 µg/L) during the September 1996 sampling event. Data collected in 1994 from MW-10 demonstrated the absence of all aromatic hydrocarbon compounds. Information from MW-10 has been used to define the downgradient extent of volatile aromatic impact from the gasoline storage and distribution system. Monitoring well MW-8, located upgradient of the dispenser island and adjacent to the northern boundary of the site, has consistently demonstrated the absence of volatile aromatic hydrocarbon compounds. However, as mentioned previously, CVOCs were detected in this upgradient well and are considered indicative of the regional impact to the Tutu Aquifer from upgradient sources.

2.4.3 Regional Ground-Water Quality

Ground-water analytical data have consistently demonstrated the absence or near absence of chlorinated organic compounds in monitoring wells located immediately downgradient of the USTs and dispenser island. Specifically, chlorinated compounds were not detected in wells SW-1 and SW-3 during the 2.5 year sampling program. Monitoring well SW-2, located along the eastern edge of the station property, exhibited a maximum individual chlorinated compound concentration of 32 µg/L (1,2 DCE).

Data from on-site monitoring well SW-8, as well as monitoring points CHT-2 and the MW-9 well cluster, have consistently demonstrated the absence of significant concentrations of chlorinated volatile organic compounds in the water table aquifer. Monitoring wells SW-8, CHT-2, and the MW-9 cluster are located 40 to 60 feet downgradient of the north oil/water separator.

Monitoring wells MW-10 and MW-10D, located approximately 50 feet downgradient of the Esso Tutu Service Station, each demonstrated detectable concentrations of certain chlorinated volatile organic compounds. Reported concentrations at these locations are consistent with those observed in well MW-8 located at the northern (i.e., upgradient) property boundary of the service station, as well as further north of the service station. They are indicative of the regional impact of the Tutu Aquifer (northern CVOC plume emanating from the former LAGA facility). The maximum individual chlorinated volatile organic compound concentration detected in this well cluster was 110 µg/L (1,2 DCE).

2.4.4 Distribution of Phase-Separated Hydrocarbons

Phase-separated hydrocarbons have been detected in two areas of the site: 1) proximal to the USTs and dispenser island; and, 2) proximal to the north oil/water separator. Phase-separated hydrocarbons present proximal to the USTs and dispenser island have been identified in monitoring wells SW-3 and CHT-3. Based upon historical well gauging data, monitoring wells SW-3 and CHT-3 have only recently exhibited the presence of phase-separated hydrocarbons. Information collected in 1993 and 1994 demonstrated the absence of free phase hydrocarbons in both wells. However, data collected in 1996 demonstrated the presence of phase-separated hydrocarbons in both SW-3 and CHT-3, with an apparent product thickness ranging from 0.01 feet to 0.40 feet (Table 2–4). The phase-separated hydrocarbons present in these two wells are similar and exhibit chemical characteristics of weathered gasoline. Monitoring well SW-2, located along the eastern edge of the site has never demonstrated the presence of phase-separated hydrocarbons. In addition, monitoring well SW-1, located between wells SW-3 and CHT-3, and immediately downgradient of the USTs, has also never demonstrated the presence of phase-separated hydrocarbons.

Phase-separated hydrocarbons have consistently been observed in well SW-7 (perched water zone), located downgradient of the north oil/water separator. Measurements collected in 1996 demonstrated an apparent product thickness ranging from 0.01 to 0.34 feet. Based upon laboratory analytical data, as well as field observations, phase-separated hydrocarbons present at SW-7 are distinctly different than those observed at monitoring wells SW-3 and CHT-3. The product sample obtained from well SW-7 was characterized as motor oil.

A transient occurrence of floating product was detected in monitoring wells MW-9 and MW-9S, located approximately 60 feet south of the north oil/water separator, between September and November 1992. Specifically, a product sheen was observed on only one occasion in well MW-9S ranging in thickness from a sheen to 0.11 feet. Subsequent measurements during 1994 and 1996 in these two wells demonstrate the absence of a free-floating product layer. Phase-separated hydrocarbons have not been detected in any other wells at or proximal to the Esso Tutu Service Station.

CVOCs were not detected in the product sample collected from well SW-7 screened in the perched water zone downgradient of the north oil/water separator (Table 2-5). The absence of CVOCs in the product sample was confirmed in a split-sample collected by EPA.

SECTION 3.0

INSTITUTIONAL CONTROLS

The remedy outlined in EPA's August 5, 1996 ROD included institutional controls for the site. The institutional controls are required to: 1) place limitations on property usage and 2) ensure the excavation/disturbance of soil will not occur without a permit. Based on the findings of EPA's Baseline Human Health Risk Assessment, surface soil and subsurface soils were found to pose an acceptable risk to human health for workers under both current conditions and a future use scenario involving workers conducting excavation activities. Presently, the service station property is completely paved and surface soil is not available for contact. The institutional controls will be the following:

- future property use will be limited to commercial or industrial use only (e.g., not residential);
- excavation, transportation, and usage of soil or rock from impacted areas will not occur without EPA and DPNR approval.

The institutional controls listed above will be implemented by amending the deed to include these restrictions. If the residual levels of the chemicals of concern present in surface and subsurface soils are reduced through implementation of the Source Control Plan, and thereby pose no significant risk to human health, safety or the environment, EPA will be petitioned to remove the deed restrictions.

SECTION 4.0

SOURCE CONTROL PROGRAM DESIGN CRITERIA AND OBJECTIVES

The Source Control Program for the Esso Tutu Service Station is designed to remediate petroleum hydrocarbons and chlorinated volatile organic compounds present in site soils (Remedial Work Element I), and dissolved and phase-separated petroleum hydrocarbons present in ground water emanating from the Esso Tutu Service Station (Remedial Work Element II). Remedial Work Element I will incorporate soil vapor extraction and bioventing systems with treatment via catalytic oxidizer to remediate contaminated soils. Remedial Work Element II will incorporate manual bailing of free-phase product and a total fluids extraction system with treatment via air stripper and granular activated carbon to remediate contaminated ground water. This section provides a detailed description of the objectives, design criteria, and remedial system components of the Esso Tutu Service Station Source Control Program.

4.1 Objectives of Source Control Program

Specific objectives of Remedial Work Element I (Soil Remediation) of the Esso Source Control Program include:

1. Reduction of residual contaminant mass in vadose zone soils. Although vadose zone modeling of existing soil quality data indicates that residual contaminant mass will not leach to the Tutu Aquifer at concentrations that would result in exceedance of Federal MCLs, unsaturated zone remediation will be performed because access limitations proximal to the gasoline dispenser island did not allow for the collection of potentially "worst case" BTEX impacted soils directly beneath the dispensers. Therefore, soils with BTEX concentrations which could adversely impact ground-water quality potentially exist in this area but have not been sampled.

2. Removal of mobile-phase product and dehydration of the perched zone through manual bailing and total fluids extraction.

3. Removal of petroleum hydrocarbons in a state of residual saturation from the perched ground-water system will require the implementation of soil bioventing. Although phase-separated hydrocarbons (PSH) in this area exhibit a limited quantity of BTEX compounds and no chlorinated volatile organic compounds (CVOCs), removal of PSH is required by EPA.

Specific objectives of Remedial Work Element II (Ground-Water Remediation) of the Esso Source Control Program include:

1. Removal of PSH present in on-site and off-site monitoring wells through: 1) total-fluids pumping, 2) manual bailing, and 3) deep SVE in the PSH smear zone. PSH (gasoline) has been observed intermittently at three well locations: SW-3, SW-7, and CHT-3.

2. Remediation of dissolved aromatic compounds in the shallow portion of the Tutu aquifer beneath and downgradient of the Esso Tutu Service Station. Remediation efforts are designed, to the extent possible, to reduce concentrations of aromatic constituents to levels consistent with Federal Drinking Water Criteria.

Elements of each remedial objective are presented below. Remedial system configurations for Remedial Work Elements I and II are illustrated in Figure 4-1.

4.2 Design Criteria - Remedial Work Element I (Soil Remediation)

Remedial activities in the vadose zone soils will consist of soil vapor extraction (SVE) and bioventing. SVE will be performed concurrently with dewatering of the perched water-bearing zone and PSH removal to more effectively achieve contaminant mass removal. Bioventing remedial activities will be performing subsequent to dehydration of the perched water zone. Remedial activities in the saturated zone soils will consist of ground-water recovery (and associated dewatering) and treatment, as well as PSH removal (see Sections 4.3.1 and 4.3.2).

To the extent practical, the site-specific Soil Screening Levels (SSLs) established by the ROD will be the target contaminant clean-up concentrations for Remedial Work Element I. The following SSLs for individual contaminants were established for the Esso Tutu Service Station:

Compound	Depth (feet below surface)	Site-Specific Soil Screening Level
BTEX Compounds	0.0 - 8.7	74 µg/L
CVOCs	0.0 - 8.7	320 µg/L
BTEX Compounds	8.7 - 15.0	15 µg/L
CVOCs	8.7 - 15.0	32 µg/L

It is expected that after a continued period of SVE operation, total contaminant mass removal, or remaining concentrations in soils (as measured indirectly through vapor monitoring), will exhibit minimal change, and begin to approach an asymptotic limit of mass or concentration. Once the asymptotic limit is reached via SVE, bioventing will be initiated in the area of the north oil/water separator (see Section 4.2.1.1). Continued bioventing activity will also subsequently reach a secondary, albeit lower, asymptotic limit. Although Remedial Work Element I is expected to achieve significant soil contaminant mass removal, the final asymptotic limit (and its relationship to the corresponding SSL) cannot be determined with certainty until actual operation of the remedial system.

If the asymptotic levels achieved via Remedial Work Element I (i.e., SVE, and where applicable, bioventing) are less than the SSLs tabulated above, a request will be submitted to EPA for approval to terminate soil remediation activities. Should asymptotic levels remain above the SSLs, EPA/DPNR will be notified and Remedial Work Element I Contingency Measures described in Section 5.2 will be invoked. A complete analysis of the remedial system's performance, the effectiveness of the Contingency Measures, and an evaluation of all applicable alternate technologies, will be prepared and submitted to EPA/DPNR for review, if the Performance Standards outlined in Section 5.1 cannot be achieved for Remedial Work Element I.

4.2.1 Vadose Zone Soils

For the purposes of this report, the vadose zone is defined as those areas which are unsaturated, or which will become unsaturated as a result of ground-water and PSH extraction. The term "soil impact" identifies soils which contain contaminants of concern above EPA's SSLs, as presented in the ROD. Two general areas of vadose zone soil impact exist at the Esso Tutu Service Station. These areas of soil impact, and a listing of contaminants detected above their respective SSLs, are as follows:

Dispenser Island/Product Delivery Lines

Benzene	Toluene
Ethylbenzene	Xylene

North Oil/Water Separator

Benzene	Toluene
Ethylbenzene	Xylene
1,1-Dichloroethane	Tetrachloroethene
1,2-Dichloroethene	Trichloroethene
1,1,1-Trichloroethane	

As noted above, the dispenser island/product delivery line area and the north oil/water separator are characterized by the presence of aromatic constituents. Vadose zone soils proximal to the north oil/water separator also exhibit the presence of several CVOCs above SSLs.

Remedial activities will be performed in two areas of the subject site to reduce contaminant mass in the vadose zone. The two areas targeted for vadose zone remediation include the north oil/water separator (including the area south of the separator) and the dispenser island/UST area.

4.2.1.1 North Oil/Water Separator

Vadose zone remedial activities proximal to the north oil/water separator will involve SVE and bioventing. Initiation of vadose zone remediation will occur contemporaneous with dewatering of the perched ground-water zone and the removal of PSH, as discussed in Sections 4.3.1 and 4.3.2. SVE and bioventing will be performed to remove residual contaminant mass sorbed onto the soil matrix.

SVE will be utilized to remove volatile organic compounds (e.g., BTEX, PCE, TCE, and DCE) detected in soil samples immediately west of the north oil/water separator. Bioventing, which will be implemented subsequent to SVE operations, will be employed to remediate non-volatile constituents and petroleum hydrocarbons in residual saturation. The configuration of the SVE and bioventing systems is presented in Figure 4-1.

SVE will be performed at wells V1 and V2 installed proximal to the north oil/water separator. Well V1 will be located approximately 15 feet north of the separator, while well V2 will be positioned 10 feet south of the separator (Figure 4-1). The wells will be installed to a depth of approximately 15 feet, with 10 feet of screen placed in the 5 to 15-foot interval. The 3 to 12-foot interval immediately west of the north oil/water separator represents the zone of highest volatile organic concentrations in this area, and is the area targeted for remediation. The SVE wells will be constructed of 2-inch diameter PVC pipe, and completed with a 2-foot square concrete vault, constructed flush with the surrounding grade (for well construction details, see Figure 4-2).

Each of the SVE wells will be connected to a PVC manifold, installed in the main trench running parallel to the western property boundary (Figure 4-1). The manifold header will be connected to a vacuum blower, operating at a flow rate of approximately 15-20 cubic feet per minute (cfm) per SVE well. Vapors extracted from the SVE wells will be treated via a catalytic oxidizer unit. Effluent from the catalytic oxidizer will then be discharged to the atmosphere in accordance with DPNR regulations.

In Figure 4-3, vapor capture zones observed during the 1996 pilot testing program have been superimposed on known extent of soil impact above applicable SSLs to illustrate the calculated/expected zone of SVE/biovent capture. Site data indicate that the spatial distribution of volatile organic compounds is limited, and that two SVE wells should encompass the area of concern. At present, it is anticipated that the SVE system will operate for approximately 12 to 24 months. The transition from SVE to bioventing will be determined based upon field monitoring and/or laboratory analysis of vapor concentrations during system operation, as discussed in Section 5.1.

Concurrent with, and subsequent to the SVE program at the north oil/water separator, bioventing activities will be performed to reduce the mass of the semi- and nonvolatile biodegradable hydrocarbon compounds. The bioventing program proximal to the north oil/water separator will consist of two distinct areas. A description of each of the two areas follows:

1. One area will be used to remove residual petroleum mass immediately adjacent to the separator. Bioventing in this area will commence upon completion of SVE activities. Two bioventing extraction wells will be installed adjacent to the separator, BE1 will be located 10 feet to the northwest, and BE2 will be located 5 feet to the southeast of the separator, respectively. Bioventing injection will be accomplished through two wells used to supply air to the subsurface. One well (BI) will be installed as a bioventing injection well; the second well will be an existing ground-water extraction well converted for use as a bioventing injection well (G1/B1). No additional construction or modification to the ground-water extraction well will be required to implement bioventing injection. The three bioventing wells will be installed to a depth of approximately 15 feet, with 10 feet of screen placed in the 5 to 15-foot interval.

2. The second bioventing area associated with the north oil/water separator will be located south of the separator, in the alleyway between the station building and the southern property boundary (Figure 4-1). Bioventing in this area, comprised of three extraction and three injection wells, will commence upon dehydration of the perched water zone and removal of floating PSH, to the extent possible. The bioventing extraction wells (BE3, BE4, BE5) will be installed in a linear east-west array, along the southern portion of the alleyway. Three shallow ground-water extraction wells (G2/BI, G3/BI, G4/BI) will be converted to injection wells following dehydration of the perched water zone. These wells are located along the northern portion of the open garage, parallel to the

extraction wells. This area is interpreted as being proximal to the source of PSH (e.g., the north oil/water separator), and therefore thought to be characterized by the maximum thickness of free product. In contrast to the distribution of contamination adjacent to the separator, the maximum zone of impact in the alleyway is present at a depth of 9 feet to 12 feet. Soils present at depths shallower than 9 feet have demonstrated the absence of significant concentrations of volatile organic compounds, as well as other petroleum constituents.

Each of the five bioventing extraction wells (BE1 through BE5) and bioventing injection well B1 will be constructed of 2-inch diameter PVC well pipe, installed to a depth of 15 feet below grade (for well construction details, see Figure 4-2). Four shallow ground-water recovery wells will be converted for use as bioventing injection wells, and as such their construction will be 4-inch PVC (for well construction details, see Figure 4-4). All wells will be screened from 5 feet to 15 feet below grade to target the interval of maximum residual mass.

Bioventing extraction wells will be connected to a PVC manifold, installed in a trench in the central portion of the open garage (Figure 4-1). The manifold header will be connected to a vacuum blower, operating at a flow rate of approximately 3 to 5 cfm per well. Vapors extracted from the bioventing wells will be treated via the catalytic oxidizer unit installed as part of the SVE system. If the expected significantly decline in vapor concentrations occurs after continued operation of the bioventing system, treatment of the extracted air may be changed to vapor GAC, or the vapor may be discharged directly to the atmosphere in accordance with DPNR regulations. Bioventing injection wells will be connected to a separately manifolded system used to distribute "ambient air". The estimated duration of the bioventing system is approximately 24 to 36 months, with actual termination of the system based upon field measurements and/or laboratory analysis of vapor concentrations as part of the system monitoring program, as discussed in Section 6.1.

4.2.1.2 Dispenser Island (and UST area)

SVE will be performed proximal to the dispenser island, distribution piping, and USTs to remediate soils impacted by releases of gasoline (Figure 4-1). As stated previously, soils directly beneath the dispenser island have not been extensively sampled, however, based upon ground-water quality data and field observations during the installation of dispenser containment pans in 1995, soils impacted with gasoline product were present directly beneath the dispensers and the distribution piping. In addition, well gauging efforts have indicated the presence of PSH at well SW-3, located approximately 7 feet south of the dispenser island.

SVE will also be performed immediately south of the USTs, proximal to well CHT-3. Although this area is not identified as having vadose zone impacted soils, SVE will be performed to remove sorbed contaminant mass from the fractured bedrock regime during ground-water/PSH extraction activities (see Sections 4.3.1 and 4.3.2).

The SVE program for the dispenser island area will consist of a vertically integrated extraction network (Figure 4-1). A shallow well V3 (set at a total depth of 15 feet) will be utilized to remove residual mass directly beneath the pump island, in the interval from 3 feet to 10 feet below grade (bedrock is present at depths of 8 feet to 10 feet in the general vicinity of the pump island). Vapors will be extracted at a rate of approximately 20 cfm. Based upon SVE pilot test activities conducted in September 1996, flow rates of this magnitude will create a radius of influence which encompasses a majority of the front portion of the station property, including the entire dispenser island and significant portions of the distribution piping area (Figure 4-3).

Deep SVE wells associated with the SVE dispenser island network (V-4), as well as the UST area (V-5), will each be utilized to remove residual PSH from the bedrock aquifer as the water table is lowered during ground-water remediation efforts. Operation of SVE in the interval of 15 feet to 30 feet below grade at each point will remove residual mass smeared on fractured bedrock as the water table, and thus free product, is lowered due to fluid extraction activities (depth to ground water under static conditions is 17 to 20 feet below grade). It is estimated that a vapor flow rate of 15 to 20 cfm will be applied to each location to remove residual mass.

Each of the three SVE wells associated with the vadose remediation program in the area of the dispenser island and USTs will be constructed of two-inch diameter PVC, with screens ranging from 10 feet in length (shallow well) to 15 feet (deep wells). Well construction diagrams are illustrated in Figure 4-2. Each vapor extraction point will be completed with a subsurface vault, installed flush with the existing grade.

SVE activities proximal to the dispenser island and USTs are anticipated to require 24 months of operation. Similar to vadose zone remedial efforts in the areas discussed above, termination of the remedial program will be based upon the rate at which soil vapor concentrations approach an asymptotic limit. Performance criteria and monitoring associated with the SVE system are discussed in Sections 5.0 and 6.1.

4.2.1.3 Remedial Work Element I - Piping System Layout

The piping layout associated with vadose zone remedial efforts will consist of three manifolded networks (detailed piping layout design drawings are included in Appendix A):

- Dispenser Island/UST & North Oil/Water Separator SVE Extraction
- North Oil/Water Separator Bioventing Extraction
- North Oil/Water Separator Bioventing Injection

One manifold system will connect all SVE wells. The extraction manifold will connect the three SVE wells located in the UST and dispenser island area. This manifold pipe will be 3-inch diameter PVC, installed below grade. The extraction manifold will also connect the two SVE wells proximal to the north oil/water separator. The manifold pipe in this area will be expanded to 4-inch diameter PVC, installed below grade. Each SVE well will be equipped at the wellhead with a valve to regulate air flow to allow greater flexibility with respect to altering flow rates in various areas and isolating portions of the remedial system. Each SVE well will also be equipped with a flowmeter (velocity) and vacuum indicator, so that individual air flows can be determined for each SVE well.

Two of the manifolds will be associated with the bioventing system, one for the collection of vapors, and the second utilized to facilitate the injection of ambient air. The extraction manifold will connect each of the five biovent points within the alleyway and proximal to the north oil/water separator. Similarly, air injection associated with bioventing activities will be accomplished through five points, all connected to a single manifold leading from the treatment area. All manifold pipe will be 3-inch diameter PVC, installed below grade. Each bioventing well will be equipped at the wellhead with a valve to regulate air flow to allow greater flexibility with respect to altering flow rates in various areas and isolating portions of the remedial system. Each bioventing well will also be equipped with a flowmeter (velocity) and vacuum/pressure indicator, so that individual air flows can be determined for each well.

4.2.1.4 Remedial Work Element I - Treatment System Layout and Controls

Soil vapors will be extracted from the five SVE and five bioventing extraction wells using a skid-mounted, Rotron-brand Model EN-CP6, explosion-proof, regenerative blower (see Appendix B for manufacturer's specification sheets). Extracted vapors will be pulled through a 30-gallon capacity moisture separator, an in-line filter, and the blower (see Process Flow Diagram, Appendix B). The moisture separator is equipped with a probe-controlled pump which directs accumulated fluids to the ground-water treatment system's oil/water separator (see Section 4.3.1.3). If the moisture separator reaches a high-level fault, or if differential pressures build up in the in-line filter or the blower, the blower will deactivate and shut down the vapor extraction and bioventing injection systems. Bioventing injection air will be supplied by a regenerative blower equipped with an inlet particulate filter. The injection blower will be deactivated if differential pressure builds up at the inlet filter or at the blower discharge.

Vapor treatment will be provided by a catalytic oxidizer (ThermTech-brand, Model #VAC-25, see Appendix B for manufacturer's specification sheets) which will discharge to the atmosphere in accordance with DPNR regulations. Catalytic oxidation is the most appropriate technology for initially treating system effluent; this technology will provide efficient destruction of the elevated vapor concentrations expected during the early operation of the remedial system with minimal maintenance and monitoring. For safety and fire code regulations, the vapor treatment system will be housed in its own treatment enclosure (see Process and Instrumentation Diagram, Appendix B). The catalytic oxidizing unit will deactivate, and the vapor extraction system (and bioventing injection) will turn off, if the unit is not operating within the proper temperatures range, or if influent pressure falls below pre-set levels. The remedial system's telephone dial-out feature will be configured to notify the operator whenever the system is deactivated.

4.2.1.5 Remedial Work Element I - Design Calculations

Based on pilot test results, the anticipated air flow from each of the five SVE wells is estimated at 15 to 20 cfm under 20 inches of water column (wc). Anticipated air flow from each of the five bioventing extraction wells is estimated at 3 to 5 cfm at 20 inches wc, for a total estimated vapor extraction air flow of 90 to 125 cfm. The regenerative blower which will be used for the system has a capacity of approximately 175 cfm at 20 inches wc (a pump curve for the blower is provided in Appendix B), or an additional capacity of 50 cfm at the expected operating vacuum. This additional capacity should be more than adequate to address potential expansion of the vapor extraction system, if required, as various SVE and bioventing extraction wells will be taken "off-line" when asymptotic contaminant mass recovery conditions are reached at individual wells. However, if necessary, the catalytic oxidizer has a maximum capacity of approximately 225 cfm; an additional blower could be incorporated into the system to reach the maximum capacity of the catalytic oxidizer.

Typically, bioventing injection air flow rates are similar to the bioventing extraction rate. The system's bioventing injection compressor will be capable of delivering up to 12 cfm at 20 inches wc to each of the five bioventing injection wells. The individual well injection rate can be reduced to allow the incorporation of more bioventing injection wells into the system.

Based upon calculations of expected contaminant mass (derived from laboratory analysis of vapor samples collected during SVE pilot testing in September/October 1996) and expected vapor flow rates, the total VOC mass removed from the subsurface during initial portions of the SVE/bioventing program will be approximately 5 pounds per day. Vapor calculations are summarized in Table 4-1a, which incorporates average soil vapor concentrations obtained during pilot testing, and Table 4-1b, which incorporates maximum soil vapor concentrations obtained during pilot testing. The catalytic oxidizer is specified to provide a minimum of 95% contaminant destruction; the resulting air emission contaminant mass from the vapor extraction system will be approximately 0.019 pounds per day (maximum 0.043 pounds per day).

Influent concentrations to the treatment system will be monitored during system operation to evaluate whether the vapor-phase treatment technology should be modified (i.e., vapor-phase GAC) or eliminated at some point in the future. Prior to startup of SVE operations, all applicable air discharge permits will be secured from DPNR. Additional details regarding air discharge permit monitoring and sampling can be found in Section 6.1.

4.2.2 Saturated Zone Soils

Remediation of the saturated zone will consist of ground-water recovery (dewatering of the perched water zone) and treatment, and PSH removal (see Sections 4.3.1 and 4.3.2). These activities will address recoverable free product and dissolved contaminants. A primary goal of the overall ground-water remedial system is to expose and/or dewater shallow saturated zone soils, and thus enhance vadose zone remedial activities such as SVE and bioventing (see Section 4.2.1).

4.3 Design Criteria - Remedial Work Element II (Ground Water)

Ground-water remedial activities will consist of PSH recovery and ground-water recovery and treatment. These activities will be implemented in both the perched water-bearing zone and the shallow portion of the Tutu aquifer underlying the Esso Tutu Service Station.

Recovery of PSH will initially be implemented through periodic manual bailing of product from appropriate wells and total fluids extraction into an oil/water separator. Termination of the manual bailing program will occur when free product is no longer detected at significant thicknesses (i.e., greater than 0.05 feet) in area wells.

As specified in the Tutu Wellfield ROD, the regional aquifer is classified as a potable drinking water supply. As such, ground-water remediation standards are dictated by Federal Maximum Contaminant Levels (MCLs) and drinking water standards established by the Federal EPA. Contaminants of concern in ground water (identified in the ROD), attributable to operations at the Esso Tutu Service Station, are limited to volatile aromatic hydrocarbons (benzene, toluene, ethylbenzene, and xylenes). These compounds, and their associated MCLs, are as follows:

Compound	Federal MCL
Benzene	5 µg/L
Toluene	1,000 µg/L
Ethylbenzene	700 µg/L
Xylenes	10,000 µg/L

The above concentrations will be used as target cleanup goals for ground-water remedial activities included as part of the Esso Source Control Program. The goal of the ground-water remedial program will be to reduce the concentration of aromatic hydrocarbons emanating from the Esso Tutu Service Station to Federal MCLs to the extent practical in the localized/shallow portion of the Tutu aquifer beneath, and immediately downgradient of the subject station. For the purposes of the Esso Source Control Program, the shallow portion of the Tutu aquifer is defined as being present within approximately 40 feet of ground surface. The spatial distribution of aromatic hydrocarbons in the shallow aquifer was discussed in Section 2.4.

4.3.1 Phase-Separated Hydrocarbons (PSH)

The remedial program for the Esso Tutu Service Station will incorporate the removal of phase-separated hydrocarbons (PSH) from both on-site and off-site locations. As previously discussed, PSH has been observed on an intermittent basis at wells SW-7, CHT-3, and SW-3. Monitoring well SW-7 is screened in the perched water zone, which is present south of the north oil/water separator. Wells CHT-3 and SW-3 are screened in the shallow portion of the regional aquifer. CHT-3 is located on the adjacent Splash-n-Dash property, just south of the existing Esso UST field, while SW-3 is located proximal to the Esso dispenser island.

The extent and distribution of PSH is limited both horizontally and vertically. The spatial extent of PSH at SW-7 is limited by the size of the perched water zone, which is estimated to be less than 2,500 square feet. The absence of PSH in monitoring well SW-1 serves to separate the two free product areas observed at CHT-3 and SW-3, which are isolated from one another by approximately 35 feet.

The maximum "apparent" thickness of PSH ever detected in any well at, or proximal to, the Esso Tutu Service Station is 0.34 feet (SW-7, September 19, 1996). Although product baildown tests have not been performed at the Site, field observations suggest that the "true" thickness is most likely in the range of 0.01 feet to 0.10 feet. This range is supported by well gauging information collected during, and subsequent to, pumping test activities which indicated that free product accumulation in site wells did not exceed 0.05 feet. Using a "true" PSH thickness of 0.05 feet, the estimated product volume at each of the three areas is:

Location	Estimated PSH Volume
SW-7	230 gallons
CHT-3	15 gallons
SW-3	30 gallons

These estimates were calculated using an assumed porosity of 0.25 for the unconsolidated soils proximal to SW-7, and 0.15 for the two bedrock wells.

4.3.1.1 Perched Water-Bearing Zone

PSH removal in the perched water-bearing zone will be accomplished through total fluids extraction and periodic manual bailing. The four extraction wells (G1, G2, G3, G4) installed proximal to the north oil/water separator (Figure 4-1) will each be drilled to depths of approximately 15 feet below grade. Construction of wells will include the following (for well construction details, see Figure 4-4):

- 4-inch diameter well casing and screen (PVC);
- 10 feet of 0.01 slot well screen, placed at depths of 5 feet below grade to the well bottom;
- 5 feet of well riser placed from ground surface to a depth of approximately 5 feet below grade; and,

- completion of a well vault flush with the surrounding grade.

Due to the shallow depth at which the wells will be installed, as well as the anticipated short duration of the extraction program, it has been concluded that PVC well pipe, and not stainless steel, be used for well construction. Each well will be equipped with a pneumatic total fluids extraction pump and connected to a manifold system at the on-site treatment area, located in the northwestern portion of the station property. Based upon pumping test data and site hydrogeologic data, each well will extract water at an estimated rate of 0.25 gpm to 0.5 gpm.

Recovery of PSH will be implemented through total fluids extraction and periodic manual bailing of product from appropriate wells. It is anticipated that ground-water extraction activities in the perched zone proximal to the north oil/water separator will operate for a period of 6 to 12 months. Termination of the PSH program will occur when free product is no longer detected at significant thicknesses (i.e., greater than 0.05 feet) in area wells or when the perched zone has been dehydrated. A monitoring program will be instituted to document the presence and elevations of liquids in each well.

Subsequent to completion of PSH recovery and perched zone dehydration, the bioventing system will be activated to remove residual petroleum mass sorbed to dewatered soils. The bioventing system, as discussed in Section 4.2.1, will include five extraction wells and five injection wells.

4.3.1.2 Localized/Shallow Portion of the Tutu Aquifer

PSH recovery from the shallow Tutu aquifer will be performed at locations proximal to CHT-3 and SW-3. Due to the low yield of existing wells in these areas, new wells are planned to accommodate greater flow rates. PSH recovery within and proximal to CHT-3 and SW-3 will be accomplished through total fluids extraction and/or periodic manual bailing. Concurrent operation of the SVE system in these areas will also enhance PSH removal.

One well will be installed downgradient from CHT-3 and one well will be installed adjacent to SW-3 to facilitate recovery of ground water and PSH (Figure 4-1). Each well will be installed to a depth of 60 feet below grade to facilitate extraction of ground water. Each of the two wells will also be utilized as part of the hydraulic control program, discussed in Section 4.3.2. Construction of the wells will be as follows (for well construction details, see Figure 4-5):

- 6-inch diameter well casing and screen (stainless steel);
- 45 feet of 0.01 slot well screen, placed at depths of 15 feet below grade to the well bottom;
- 15 feet of well riser placed from ground surface to a depth of approximately 15 feet below grade; and,
- completion of a well vault flush with the surrounding grade.

Despite the fact the two proposed wells are to be completed as bedrock wells, field observations suggest that shallow portions of the bedrock formation are not competent. As such, the recovery wells will not be completed as open hole wells.

Each well will contain a dedicated pneumatic pump and will be connected to the treatment system. The planned extraction rate for each of the two PSH recovery wells is estimated at 0.5 gpm to 1.0 gpm. Termination of the PSH recovery program will occur when free product is no longer detected at significant thicknesses (i.e., greater than 0.05 feet) or is no longer recoverable from site wells. Subsequent to completion of the PSH recovery phase, pumping activities will continue to recover contaminated ground water. Ground-water extraction from the two wells is expected to extend over a minimum period of approximately 5 years as part of the Source Control Program. A monitoring program will be instituted to document the absence of PSH from site wells.

Concurrent with free product bailing and the ground-water extraction program, the SVE system will be activated to remove residual petroleum mass sorbed to dewatered soils/consolidated rock. The SVE system will include two extraction wells proximal to the dispenser island, and one well in the area of CHT-3. Details regarding the design and operation of the SVE system were discussed in Section 4.2.1.

4.3.1.3 PSH Recovery Piping and Treatment System Layout

The piping system associated with operation of the PSH recovery program is illustrated on Figure 4-1. Detailed engineering plans for the piping system and treatment area are included in Appendix A. Each extraction well will be equipped with a top-loading, total fluids pump to maximize the amount of recovered PSH. Total fluids extracted from the targeted wells will be transferred to the treatment area in the northwestern portion of the Esso Tutu Service Station property. Extracted fluids will be transferred via individual piping (PVC hose) from each recovery well. All recovery lines will be enclosed by secondary containment lines (4-inch diameter PVC pipe), which will drain into water-sealed "pulling stations". The entire piping system will be placed below grade.

Extracted fluids will be transferred to a manifold at the treatment area and passed through an oil/water separator (OWS) for gravimetric separation of any PSH that has been extracted as part of total fluids pumping. Fluids which have accumulated in the vapor extraction moisture separator (see Section 4.2.1.4) will also be directed to the OWS. A process flow diagram, which illustrates all components of the treatment system, is included in Appendix B. PSH accumulated through the separation process, as well as through manual bailing efforts, will be disposed at an off-site location, to be determined subsequent to waste characterization analysis. The aqueous phase effluent from the separator will be treated as discussed in Section 4.3.2.

4.3.2 Dissolved VOCs

Ground-water remedial activities will be implemented in both the perched water-bearing zone and the shallow portion of the Tutu aquifer underlying the Esso Tutu Service Station. Ground-water remedial efforts will be conducted concurrently with the removal of PSH.

4.3.2.1 Perched Water-Bearing Zone

As discussed in Section 4.3.1, total fluids extraction from the perched water-bearing zone proximal to the north oil/water separator will be facilitated through four recovery wells (Figure 4-1). The objective of the extraction process in the perched water-bearing zone will be to dewater this unit so that SVE and bioventing operations will be able to more effectively remove contaminant mass. As such, the four extraction wells will function as well points, serving to draw down the level of water throughout the entire perched zone.

In conjunction with dewatering activities in the area proximal to the north oil/water separator, the source of the water to this unit will be identified and mitigated to the extent possible. Based upon field observation recorded in 1993 and 1996, there does not appear to be any horizontal flow of water onto the Esso Tutu Service Station that is contributing water to the perched zone. At present, it is believed that the source of water in the perched zone is related to the cistern located beneath the station building, or infiltration of storm water through cracks/voids in the pavement. Identification of the actual source of water will be performed through an evaluation of cistern integrity.

The four extraction wells to be installed proximal to the north oil/water separator will each be drilled to depths of approximately 15 feet below grade. Construction of wells will include the following (for well construction details, see Figure 4-4):

- 4-inch diameter well casing and screen (PVC);

- 10 feet of 0.01 slot well screen, placed at depths of 5 feet below grade to the well bottom;
- 5 feet of well riser placed from ground surface to a depth of approximately 5 feet below grade; and,
- completion of a well vault flush with the surrounding grade.

Each well will be equipped with a dedicated total fluids pump, extracting liquid at a rate of 0.25 gpm to 0.5 gpm. Data from pumping tests conducted as part of the Remedial Action Work Plan demonstrated that the perched water-bearing unit can sustain pumping rates of approximately 0.5 gpm. It is estimated that the dewatering system will operate for a minimum period of approximately 6 months.

4.3.2.2 Localized/Shallow Portion of the Tutu Aquifer

The ground-water remedial program has been designed to achieve two principle objectives: 1) reduction of aromatic hydrocarbon mass in the defined BTEX plume; and 2) establish localized hydraulic control to prevent BTEX plume expansion. The ground-water remedial system associated with the localized/shallow portion of the Tutu aquifer is expected to operate until concentrations in ground water are reduced to MCLs, or until concentrations demonstrate an asymptotic relationship with respect to time. Consistent with the objective of the Esso Source Control Program, remedial efforts associated with this portion of the Tutu aquifer are designed to address contamination in shallow portions of the bedrock aquifer. The Source Control Program has not been designed to address chlorinated volatile organic compounds (CVOCs) associated with the "Northern CVOC Plume", which emanates from the Curriculum Center, or the "deep" BTEX plume which emanates from the Texaco Service Station.

Ground-water extraction activities will be employed to address dissolved BTEX contamination. The downgradient extent of the dissolved BTEX plume is defined by wells MW-

10, MW-10D, CHT-7D, and MW-9. Although wells CHT-7D and MW-10D are deep wells, they provide information regarding the vertical limits of BTEX contamination.

Four deep extraction wells (G5, G6, G7, G8) will be installed to achieve the stated goal of arresting plume expansion and reducing contaminant mass. Three of the four extraction wells (G6, G7, and G8 - approximately 80 feet south of the property line) will be installed near the downgradient border of the Esso Tutu Service Station, while the fourth well (G5) will be placed proximal to the dispenser island (see Figure 4-1). New extraction wells will be installed at each of the four locations to facilitate requisite pumping rates. Construction of the four wells will be as follows (for well construction details, see Figure 4-5):

- total depth of approximately 60 feet;
- six inch diameter well;
- well screen placed from 15 feet to 60 feet below grade;
- stainless steel well screen (0.01 slot) and riser pipe; and,
- well vault completed flush with existing grade.

Installation of wells to 60 feet (versus approximately 35 feet in existing monitoring wells) and increased well diameter of 6 inches should allow for greater pumping rates. This well configuration will produce an estimated sustainable pumping rate of 1.0 gpm per well.

Analysis of pilot test data indicate that the four deep extraction wells (G5, G6, G7, G8) will achieve the stated goal of arresting plume expansion and reducing contaminant mass. Figure 4-6 was generated using an analytical hydraulic model (Quick Flow) with the following input parameters:

Hydraulic Conductivity	0.144 ft/day
Aquifer Thickness	40 feet
Hydraulic Gradient	0.03
Storativity	0.00001
Porosity	0.1
Pumping Rate	1.0 gpm

Figure 4-6 indicates that the four wells should achieve complete hydraulic control across the site at a pumping rate of 1.0 gpm, and prevent plume expansion. The downgradient extent of the capture zone developed by each of the extraction wells has been calculated to be approximately 10 feet. Figure 4-7 depicts the calculated/expected hydraulic capture zones that will be generated as a result of operation of the SCP, superimposed on the area where benzene exceeded the Federal MCL, illustrating that the four deep extraction wells will provide maximum reduction of contaminant mass. Field monitoring will be conducted subsequent to system start-up to confirm that sufficient capture has been generated (see Section 6.0).

Although the dispenser island extraction well (G5) will not be utilized as a mechanism for plume capture, this well will also be pumped at a rate of approximately 1.0 gpm. The objective of pumping this well is to remove PSH which may be floating on the regional water table, and to effectively extract dissolved aromatic hydrocarbon mass in the source area.

The ground-water remediation program will likely operate for a period of 5 years to 10 years. The compound controlling the anticipated duration is benzene, and its associated drinking water standard of 5 µg/L. Actual termination of the regional aquifer ground-water remedial program will be based upon adherence to Federal MCLs, or achievement of asymptotic concentrations. Data utilized to assess termination of the remedial system, as well as system effectiveness, will be collected through institution of a site compliance monitoring program (see Section 6.0).

4.3.2.3 Remedial Work Element II - Piping System Layout

Ground water will be recovered from each extraction well via dedicated, total fluids, pneumatic pumps. Pneumatic pumps have fewer moving parts than electrical pumps and generally provided a higher degree of reliability in environments where frequent pump cycling is expected. Using pneumatic pumps also eliminates the necessity of running electrical power to each wellhead and constructing each wellhead as an explosion-proof work area. Ground-water extraction wells in the perched water-bearing zone will utilize 2"-diameter pumps. Extraction wells in the shallow portion of the Tutu aquifer will utilize 4"-diameter pumps. Compressed air will be delivered through a manifolded system and vented at the individual wells. The air compressor will be housed in the ground-water treatment system enclosure. Each pneumatic pump is equipped with an air regulator so that pumping rates can be regulated at individual extraction wells. Each extraction well has a dedicated, in-line flowmeter to monitor individual ground-water extraction rates.

Ground water extracted from both the perched water-bearing zone and shallow aquifer will be transferred to the on-site treatment system according to the schematic presented in Figure 4-1. For ease of operation, it has been decided that individual piping systems will transfer fluids recovered from each extraction well. Remedial activities related to the shallow Tutu Aquifer are expected to require several more years than the perched extraction system, the latter is assumed to yield a larger volume of PSH.

Extracted ground water will be transferred via individual 0.5-inch diameter piping (PVC hose). Each recovery line (and compressed air line) will be enclosed within secondary containment (4-inch diameter PVC pipe) extending from the wellhead to the treatment area. Detailed engineering design plans for piping and trenching runs are provided in Appendix A. Recovered fluids will then be directed to an OWS, with subsequent treatment of water via a low-profile air stripper and aqueous-phase granular activated carbon (GAC) before ultimate discharge (see Process Flow Diagram, Appendix B). Recovered PSH from the oil/water separator and manual bailing activities will be containerized for ultimate off-site disposal.

4.3.2.4 Remedial Work Element II - Treatment System Layout and Controls

Total fluids recovered from each extraction well will be directed to a treatment building (40-foot long shipping container) installed in the northwest corner of the Esso Tutu Service Station. The treatment building will be partitioned into rated (explosion-proof) and non-rated areas. All equipment in the rated portion of the building will be manufacturer-certified as explosion-proof.

Individual extraction lines will be manifolded upon entry to the treatment enclosure (see Process Flow Diagram, Appendix B), and process flow directed to a Great Lakes OWS (see Appendix B for manufacturer's specification sheets). The OWS will gravimetrically separate PSH from recovered ground water. A decanting valve allows recovered PSH to flow to a 55-gallon capacity PSH holding tank (see Process and Instrumentation Diagram, Appendix B). The PSH holding tank is equipped with a high-level fault which deactivates the ground-water recovery system when the tank is full. The remedial system's telephone dial-out feature will be configured to notify the operator whenever the system is deactivated due to this control fault or other system control faults discussed below.

Gravity will direct process flow water from the OWS to a 500-gallon holding tank. A sequestering agent, design to prevent iron and manganese precipitation from fouling the air stripper, will also be added to the holding tank (see below). The sequestering agent will be hydrated in an 85-gallon capacity, chemical-holding tank equipped with a mixer. A calibrated dose of the sequestering agent will be directed to the holding tank by a metering pump.

The holding tank will allow equilibration of: 1) recovered ground water with the sequestering agent, and 2) individual pump cycle "slugs" containing elevated contaminant concentrations. The holding tank also acts to "balance" the flow rate to the air stripper, maximizing residence time and allowing more effective treatment. The holding tank will be equipped with a pair of level probes which will activate/deactivate a downflow transfer pump.

The holding tank will also be equipped with a high fault which will deactivate the ground-water extraction system.

Process water from the holding tank is directed by a centrifugal transfer pump through a pre-stripper filter. The filter will remove suspended sediments recovered by the total fluids pumps. The filter is equipped with a differential pressure switches that will deactivate the transfer pump and the air stripper if the filter becomes clogged (differential pressure exceeds 15 psi). Process water is then directed to a ShallowTray-brand Model 2341, low profile air stripper for treatment.

Process water will enter the top of the air stripper and cascade down via gravity through a series of four trays equipped with aerators. The air stripper is equipped with a 300 scfm blower that will pull in ambient outside and indoor air from the treatment enclosure (to remove any fugitive indoor vapors) through an in-line filter/silencer and force the air upwards through the trays. The forced air causes volatilization of contaminants in the process water; volatized compounds from the process water enter the process air stream and are discharged to the atmosphere in accordance with DPNR permit regulations (see Section 6.2). Process water accumulates in an air stripper sump and is removed from the air stripper by a transfer pump that is activate/deactivated by a pair of level probes.

The air stripper sump is equipped with a high level fault that will deactivate the ground-water recovery system if water accumulates in the sump. The air stripper and the air filter are equipped with air flow switches which will deactivate the ground-water extraction pumps if insufficient air flow is moving through the air stripper. This insures that water will not flow through the system unless it is undergoing proper treatment.

Process water from the air stripper is directed by a centrifugal transfer pump through an in-line filter bank. The two filters, which are present to remove finer particles (including precipitated iron from the air stripper) which could lower the performance of the downflow GAC vessels, are arranged in parallel to allow continued operation of the treatment system during filter changeouts. The filter bank is equipped with a differential pressure switch similar to the pre-stripper filter that will turn off the transfer pump if both filters become clogged (differential pressure exceeds 15 psi).

After passing through the filter bank, process water receives final "polish" via two, 55-gallon capacity (200 pounds of carbon) GAC vessels arranged in series. Although design calculations (Section 4.3.2.5) indicate that no secondary treatment (GAC) is required, the GAC vessels are incorporated into the treatment system as a precautionary measure. The GAC vessels will be equipped with appropriate valving and sample ports to allow unconstrained carbon changeouts and compliance sampling. If the primary GAC is receiving excess pressure (more than 15 psi), a pressure relief valve will direct process water away from the primary GAC and back to the air stripper sump, and a differential pressure switch will turn off the transfer pump. Subsequent to treatment, effluent water will be discharged to the storm sewer in Four Winds Plaza (Turpentine Run) in accordance with Esso's TPDES permit (Permit #VI00040703).

4.3.2.5 Remedial Work Element II - Design & Calculations

The ground-water treatment system, which incorporates a low-profile air stripper and secondary GAC carbon, is similar to treatment operations conducted by EPA implementation of the RI. Air stripping has consistently demonstrated effectiveness and efficiency during previous studies at the Tutu Wellfield site, and represents the most applicable technology for treating constituents detected at the Esso Tutu Service Station. Even though the air stripper has been designed to provide removal of target compounds to less than the discharge limits specified in the facility's TPDES permit (see Section 6.2), processed water from the air stripper will also polished with aqueous-phase GAC. GAC canisters (two units) will be installed in series to provide secondary treatment and to facilitate compliance monitoring.

Based on pilot test results, the anticipated recovery rate from the four "deep" ground-water extraction wells will be from 0.5 to 1.0 gpm; each of these wells will be equipped with a pneumatic pump capable of pumping at 2.0 gpm under anticipated field conditions. The anticipated recovery rate from the four "perched water" extraction wells is 0.25 to 0.50 gpm; each pneumatic pump installed in these wells will be capable of pumping up to 1.0 gpm under field conditions. The total pumping rate from the eight extraction wells is estimated at 3 to 6 gpm, although the recovery rate may be slightly higher during initial system operation. The SVE system moisture separator (see Section 4.2.1.4) may also contribute up to 1.0 gpm to the system.

The OWS, centrifugal transfer pumps, filter housing, and particulate filters can all operate at sustained flow rates of 15 gpm or greater. The GAC vessels are rated to a maximum of 15 gpm. As designed, the ground-water recovery and treatment system's capacity is limited by performance of the air stripper (see discussion below). The treatment system is designed to operate at sustained flows of 12 gpm, providing approximately 100% additional capacity under conditions expected during the first year of operation. If necessary, the system can operate within performance standards at 15 gpm for short intervals, providing an additional safety factor. Also, after a period of 6 to 12 months of continued system operation (and subsequent dewatering of the perched water zone), recovery rates from the four perched water wells will be negligible, thereby adding additional potential capacity to the ground-water recovery system.

Laboratory analytical results from ground-water samples collected during the RD pilot testing program (September/October 1996) were used to derive mass-loading calculations. Representative well(s) in the vicinity of each ground-water recovery well were used to predict contaminant concentrations during system operation. Concentrations were weighted according to expected well yield. Table 4-2 lists the representative wells selected for each extraction well, expected well yields, and ground-water contaminant estimates used for system design.

The air stripper selected for Remedial Work Element II was designed such that at a flow rate of 15 gpm and contaminant concentrations outlined in Table 4-2, the air stripper would reduce contaminant concentration to meet the discharge limits stipulated in the site's TPDES permit (see Section 6.3). The air stripper was designed using the manufacturer's proprietary software (ShallowTray Modeler v. 2.1W). A description of the software is included in Appendix B.

Projected treatment efficiencies based on estimated system contaminant concentrations are 100% (10 gpm flow rate), 100% (12 gpm), and 99.9997% (15 gpm). Results of the modeling (Appendix B) indicate that benzene, toluene, and xylene concentrations after treatment via air stripper will remain below 1 ppb at flow rates of 10, 12, and 15 gpm. Since benzene has the lowest discharge limit (15 ppb), the modeling results demonstrate that the air stripper will provide effective treatment to the process water flow at the operational flow rate of less than 10 gpm, and at the projected maximum flow rate of 12 gpm.

Mass calculations indicate that total air emissions from the air stripper will be approximately 0.078 pounds per hour. This estimate is derived assuming design volatile organic concentrations (see Table 4-2), 100 percent removal efficiency of these constituents during residence time in the air stripper, and an operational flow rate of 6 gpm. Under similar assumptions, total air emissions from the air stripper will be approximately 0.130 pounds per hour at a flow rate of 10 gpm, and 0.156 pounds per hour at a flow rate of 12 gpm. Air striper emission calculations are summarized in Table 4-3. Based upon these calculations and DPNR permitting (see Section 6.3), vapor-phase treatment of air stripper emissions is not required. However, because the catalytic oxidizer used in Remedial Work Element I possesses additional capacity (see Section 4.2.1.5), the Remedial Work Element II treatment system will be configured so that a portion of the air stripper off-gas can be directed to the catalytic oxidizer for treatment.

Influent concentrations to the treatment system will be monitored during system operation to determine whether treatment technology should change subsequent to start-up. Prior to startup of ground-water extraction and treatment operations, all applicable air discharge permits will be secured from DPNR. Additional detailed on air discharge permit monitoring and sampling can be found in Section 6.2.

SECTION 5.0

SOURCE CONTROL PLAN PERFORMANCE CRITERIA

5.1 Performance Criteria - Remedial Work Element I (Soil)

Remedial activities associated with Remedial Work Element I will consist of SVE system operation and bioventing. SVE will be performed concurrently with dewatering of the perched water-bearing zone (and PSH removal). Bioventing remedial activities will be performing subsequent to dehydration of the perched water zone. Details of the remedial activities to be performed in conjunction with Remedial Work Element I are provided in Section 4.2.

System monitoring will be performed throughout the duration of soil remedial activities to: 1) ensure technology effectiveness, 2) monitor contaminant mass removal, and 2) confirm vapor capture areas. Performance monitoring activities for the SVE and bioventing systems will include: 1) the collection of vapor samples to quantify the total mass of hydrocarbons removed, 2) the measurement of vacuum levels at extraction wells and vapor monitoring points to determine the effective radii of influence, 3) the collection of water levels to confirm dewatering of the perched water zone (necessary for initiation of bioventing), 4) the collection of vapor samples to confirm bioventing effectiveness, and 5) vapor treatment off-gas monitoring. Sampling protocol and other monitoring activities associated with the SVE/bioventing system are outlined in Section 6.0.

Vapor samples will be collected from individual SVE wells to determine contaminant mass removal (see Section 6.0). It is expected that after a continued period of SVE operation, total contaminant mass removal, or remaining concentrations in soils (as measured indirectly through vapor monitoring), will exhibit minimal change, and begin to approach an asymptotic limit of mass or concentration. Once the asymptotic limit is reached via SVE, bioventing will be initiated in the area of the north oil/water separator (see Section 4.2.1.1.1). Continued bioventing activity in this area will also subsequently reach a secondary, albeit lower, asymptotic limit.

Each SVE well is equipped with a vacuum gauge to measure applied vacuum at the wellhead. Vapor monitoring points (VMPs) in the vicinity of the SVE wells will periodically be fitted with a well seal and vacuum gauge to measure the induced vacuum at the VMP. Figure 4-3 depicts the predicted radii of influence for the SVE system based on pilot testing data. Analysis of the induced vacuum data collected during remedial system operation will provide the actual radius of influence for each SVE well under field conditions. Based on these data, the applied vacuum at individual SVE wells will be adjusted (via valving at each wellhead) to maximize/optimize contaminant mass removal from each SVE well.

Initiation of bioventing in the area proximal to the north oil/water separator is predicated on the dewatering of the perched water table. Data collected from the weekly liquid level measurements obtained during the first year of system operation will be used to determine when the perched zone has been dewatered and operation of the bioventing system can begin.

The bioventing system will consist of a series of injection and extraction wells (see Section 4.2). In the subsurface, the concentration of oxygen is often the most important limiting factor on biodegradation. The injection of ambient air (containing approximately 20.8% oxygen) via the bioventing system should stimulate microbial activity and associated biodegradation. The bioventing extraction wells will help to convey and distribute the injected air from the injection well, and exhaust the oxygen-depleted air and biodegradation byproducts, such as carbon dioxide.

Once the bioventing system is operational, vapor samples will be collected from individual bioventing extraction wells (see Section 6.0) and screened for oxygen, carbon dioxide, and methane concentrations. VMPs can also be monitored for the same gasses to determine the area of bioventing influence. Increasing oxygen levels (and decreasing carbon dioxide and methane concentrations) over time will indicate bioventing system effectiveness. Hydrocarbon biodegradation rates can be quantified using stochiometric equations (developed in Hinchee, et al, 1992) which incorporate oxygen utilization rates (and/or carbon dioxide production).

During operation of the SVE/bioventing systems, extracted vapors will be treated via catalytic oxidation. Vapor samples will be collected from the system influent manifold and the catalytic oxidizer effluent to determine the effectiveness of the catalyst and to ensure compliance with all discharge requirements.

To the extent practical, the site-specific SSLs established by the ROD will be the target contaminant clean-up concentrations for Remedial Work Element I. As discussed above, contaminant levels will reach an asymptotic limit after continued operation of the SVE/bioventing systems. Although Remedial Work Element I is expected to achieve significant soil contaminant mass removal, the final asymptotic limit for a given compound (and its relationship to the corresponding SSL) cannot be determined with certainty until actual operation of the remedial system.

Data collected from the SVE/bioventing monitoring program will be used to calculate the removal of petroleum mass from the subsurface and determine the schedule for system shut down. Once site data indicate that the hydrocarbon concentrations have reached an asymptote, confirmation soil sampling will be implemented adjacent to and south of the north oil/water separator, in the vicinity of the dispenser island, and downgradient from the UST tank field.

The confirmation sampling program will include two borings drilled adjacent to the north oil/water separator, three borings drilled south of the separator in the alleyway, and two borings drilled south of the dispenser island. One soil sample will be obtained from each boring, at the interval which demonstrates the greatest petroleum impact. Sample selection will also be based upon field criteria, specifically, PID readings, visual and olfactory observations, and depth. Soil confirmation samples will be analyzed for volatile organic compounds by EPA Method

8240, polycyclic aromatic hydrocarbons by Method 8310, and petroleum hydrocarbons (e.g., gasoline- and diesel-range organics) by Gas Chromatography, EPA Method 8015A.

Analytical data obtained during the confirmation program will be compared to the site-specific SSLs. If the data indicate that soil contaminant concentrations achieved via Remedial Work Element I are reduced to less than the site-specific SSLs, a request will be submitted to EPA for approval to terminate soil remediation activities. Should asymptotic levels remain above the SSLs, EPA/DPNR will be notified and Remedial Work Element I Contingency Measures described below in Section 5.2 will be invoked. A complete analysis of the remedial system's performance, the effectiveness of the Contingency Measures, and an evaluation of all applicable alternate technologies will be prepared and submitted to EPA/DPNR for review, if the original Performance Standards cannot be achieved for Remedial Work Element I.

5.2 Contingency Measures - Remedial Work Element I (Soil)

As discussed above, the Source Control Program (SCP) at the Esso Tutu Service Station will utilize SVE and bioventing remedial technologies during the execution of Remedial Work Element I. The SCP has been formulated based upon existing site empirical data and best professional judgment, and is consistent, to the extent possible, with the Tutu Well field ROD. Certain efforts will be instituted to monitor the effectiveness of the remedial program and to identify problems as they arise. Specifically, the following contingencies will be evaluated/implemented pending on-site developments:

1. Inability to Reduce Contaminant Mass - Vadose Zone
The vadose zone remedial program will incorporate bioventing and SVE to reduce contaminant mass. Although vadose zone modeling indicates that existing soil concentrations are protective of ground-water MCLs, remedial efforts are proposed to remove contaminant mass in areas which may not have been fully investigated or which may have been associated with a measurable quantity of phase-separated hydrocarbons. As part of these efforts, certain assumptions have been incorporated in the layout of bioventing and SVE wells so that a majority of contaminant mass may be recovered.

Collection and analysis of extraction well vapor samples, quantitative analysis of soil samples, and field monitoring of subsurface air pressure/vacuum will be performed to evaluate contaminant mass removal from the vadose zone, and determine SVE well radii of influence (see Section 5.1). Should these data indicate that remedial efforts are not effectively reducing contaminant concentrations, or that insufficient radii of influence are being produced, alternative measures will be considered. These measures could include: installation of additional SVE/bioventing wells to increase the areal extent of system influence, soil excavation/disposal, and other potentially applicable technologies such as enhanced bioremediation. The discussion to implement any/all of these measures will made after a completion evaluation of the data and discussions with EPA/DPNR.

2. Inability to Dewater Perched Zone
The dewatering program for the perched water-bearing zone is based upon the assumption that the source of water is identified and mitigated. At present, the most likely source of water is considered to be the station cistern and/or infiltration of storm water beneath the station building. In conjunction with implementation of the dewatering program, the source of water will be confirmed and mitigated.

Implementation of bioventing in the area proximal to the north oil/water separator is predicated on the ability to remove most, if not all, water present in the perched zone. The monitoring programs in this area will include the collection of water level data to determine the system's effectiveness in dewatering this area. If the perched zone cannot be dewatered utilizing the existing system, an alternate program will be developed to reduce contaminant mass in this area. Potential alternatives could include simultaneous operation of fluid extraction and bioventing systems, installation of additional dewatering wells, and soil excavation/disposal.

3. Exceedance of Air Emission Discharge Limits
Compliance monitoring will be implemented to ensure that discharge requirements are satisfied. The program for confirming compliance will be consistent with specifications stipulated in the Air Pollution Control Permit issued by DPNR. SVE/bioventing vapors will treatment will be provided by catalytic oxidation. This technology is normally an extremely effective means of contaminant removal and destruction, and it is also possible that vapor concentrations generated over time will decline to concentrations that will not require treatment. However, should compliance samples indicate that air emissions exceed applicable limitations, modifications to the existing treatment program will be developed. These

modifications could include replacement of the existing catalyst and/or installation of additional catalyst units to provide higher treatment efficiencies. These measures will be implemented as necessary to ensure that the operation of the SVE/bioventing system complies with all EPA/DPNR discharge requirements.

If any of the above concerns develop during the course of the SCP, EPA/DPNR will be notified and included in discussions related to evaluation and selection of alternative programs. As discussed above, many of the contingency issues are predicated on the collection of site monitoring and compliance data. Section 6.2 summarizes the compliance monitoring program that will be implemented as part of the Esso SCP.

5.3 Performance Criteria - Remedial Work Element II (Ground Water)

System monitoring will be performed throughout the duration of ground-water remedial efforts to ensure system effectiveness and to evaluate performance criteria. Specifically, the monitoring program will be utilized to: 1) confirm dissolved mass removal in the source area, 2) confirm the absence of plume expansion within the shallow bedrock aquifer beneath the station, 3) ensure sufficient hydraulic capture along the southern boundary of the Esso Tutu Service Station, and 4) monitor PSH removal effort.

Performance monitoring activities for the SVE and bioventing systems will include: 1) collection of ground-water quality samples from the system to quantify the total mass of hydrocarbons removed, 2) collection of ground-water quality samples from individual recovery/monitoring wells to monitor the spatial distribution of the contaminant plume, 2) measurement of liquid levels at extraction wells and monitoring points to determine the effective radii of influence, 3) collection of liquid levels to confirm dewatering of the perched water zone and removal of PSH, and 4) treated ground water and air stripper off-gas monitoring. Sampling protocol and other monitoring activities associated with the ground-water extraction system are outlined in Section 6.0.

Ground-water quality samples will be collected from system influent to calculate contaminant mass removal (see Section 6.0). Ground-water quality samples will also be collected from individual recovery/monitoring wells to track the areal extent and magnitude of the contaminant plume and confirm the absence of plume expansion beneath the Esso Tutu Service Station.

Ground-water quality data will be used to determine system effectiveness. It is expected that after a continued period of ground-water extraction, the system's total contaminant mass removal (and individual well contaminant concentrations) will exhibit minimal change, and begin to approach an asymptotic limit of mass or concentration. Once the asymptotic limit is reached, termination of Remedial Work Element II will be evaluated (see below).

Weekly liquid-level data will be collected from all on-site and proximal wells during the first year of ground-water extraction. This data will be used to calculate the radius of influence for each extraction well and the system's overall capture zone. Figure 4-7 depicts the predicted radii of influence for the ground-water system based on pilot testing data. Analysis of the liquid-level data collected during remedial system operation will provide the actual area of hydraulic control for each ground-water extraction well under field conditions. Based on these data, pumping depths/rates at individual ground-water extraction wells will be adjusted, if necessary, to ensure sufficient hydraulic capture along the southern boundary of the Esso Tutu Service Station and prevent plume expansion within the shallow bedrock aquifer beneath the station.

Effective treatment of the perched water zone is predicated on the dewatering of the perched water table. Data collected from the weekly liquid level measurements will be used to determine the effectiveness of the dewatering effort.

System monitoring will be performed throughout the duration of the PSH recovery program to ensure system effectiveness. The PSH recovery program will be terminated when free product thicknesses are consistently less than 0.05 feet in all on-site and proximal wells for a period of 12 consecutive months.

During the operation of Remedial Work Element II, total fluids extracted by the system will be processed through an oil/water separator and treated via air stripping. Water samples will be collected before and after air stripper treatment, and air stripper off-gas samples will be collected, to ensure system effectiveness and compliance with all discharge requirements. Although the air stripper has been sized and designed so that processed water will meet all discharge requirements, as a precautionary measure the treated water will also be directed through primary and secondary granular activated carbon (GAC) vessels, which will provide a final "polish". Water samples will be collected from primary GAC effluent (mid-GAC) on a periodic basis to monitor GAC loading. Monthly water samples will be collected from secondary GAC effluent (final discharge) for TPDES compliance monitoring.

Data collected from the monitoring program, as outlined in Section 6.0, will be used to determine the schedule for system shut down. Liquid-level data and ground-water quality data will be obtained throughout implementation of the SCP, estimated to last for a minimum of 5 years. These data will be utilized to confirm the absence of plume expansion, and document hydraulic capture and mass removal.

Termination of Remedial Work Element II efforts in the shallow bedrock aquifer beneath and downgradient of the Esso Tutu Service Station will be based upon compliance with Federal MCLs to the extent practical, or the observation of asymptotic concentrations. As discussed in association with Remedial Work Element I, dissolved contaminant levels will reach an asymptotic limit after continued operation of the ground-water extraction system. Although Remedial Work Element II is expected to achieve significant PSH and dissolved contaminant mass removal, the final asymptotic limit for a given compound (and its relationship to the corresponding SSL) cannot be determined with certainty until actual operation of the remedial system.

Data collected from the ground-water monitoring program will be used to calculate the removal of petroleum mass from the subsurface and determine the schedule for system shut down. Once site data indicate that the hydrocarbon concentrations have reached an asymptote, analytical data obtained during the monitoring program will be compared to the MCLs. If the data indicate that ground-water contaminant concentrations achieved via Remedial Work Element II are reduced to less than the MCLs, a request will be submitted to EPA for approval to terminate ground-water remedial activities. As stated in the UAO, subsequent to achieving these standards, three annual confirmatory sampling events will be performed.

Should asymptotic levels remain above the MCLs, EPA/DPNR will be notified and Remedial Work Element II Contingency Measures described below in Section 5.4 will be invoked. A complete analysis of the remedial system's performance, the effectiveness of the Contingency Measures, and an evaluation of all applicable alternate technologies, will be prepared and submitted to EPA/DPNR for review, if the original Performance Standards cannot be achieved for Remedial Work Element II.

5.4 Contingency Measures - Remedial Work Element II (Ground Water)

As discussed above, the SCP at the Esso Tutu Service Station will incorporate PSH recovery and ground-water extraction. This SCP has been formulated based upon existing site empirical data and best professional judgment, and is consistent, to the extent possible, with the Tutu Well field ROD. Certain efforts will be instituted to monitor the effectiveness of the remedial program and to identify problems as they arise. Specifically, the following contingencies will be evaluated/implemented pending on-site developments:

1. Insufficient Radius of Influence - Hydraulic Control
The ground-water recovery system associated with the shallow aquifer consists of a hydraulic control portion designed to arrest plume expansion. Achievement of sufficient hydraulic capture from each of the four downgradient wells will be monitored through the collection of ground-water elevation measurements and ground-water quality data, as discussed in Section 6.0.

If site data indicate that insufficient capture is being generated due to higher well yields than expected, pump upgrades will be evaluated. If site data indicate that insufficient capture is being generated due to other factors which may limit radii of influence (hydraulic conductivity, aquifer heterogeneity, etc.), and plume expansion is occurring, the need for additional extraction wells will be evaluated.

2. Inability to Dewater Perched Zone
The dewatering program for the perched water-bearing zone is based upon the assumption that the source of water is identified and mitigated. At present, the source of water is most likely the station cistern and/or storm water infiltration to the subsurface beneath the station building. In conjunction with the dewatering program, the source of water will be confirmed and mitigated.

If the perched zone cannot be dewatered utilizing the existing system, an alternate program will be developed to reduce PSH and dissolved contaminant mass in this area. Potential alternatives could include installation of additional dewatering wells, simultaneous operation of fluid extraction and bioventing systems, enhanced bioremediation, and soil excavation/disposal.

3. Occurrence of Phase-Separated Hydrocarbons
Current site data indicate that PSH is periodically present at wells SW-3, SW-7, and CHT-3. Remedial measures outlined above have been designed to address the presence of free product at these locations. Concurrent with, and subsequent to completion of phase-separated hydrocarbon activities, well gauging efforts will be performed to determine the presence/absence of free product at all on-site and proximal monitoring wells. Should free-product reappear in SW-3, SW-7 or CHT-3 (or be discovered in any on-site or proximal monitoring well) at apparent thicknesses greater than 0.05 feet subsequent to termination of recovery activities, PSH removal will be re-instituted. If necessary, the use of automated PSH pumps will also be evaluated. Performance monitoring associated with the PSH recovery system is presented in Section 6.2.

4. Exceedance of TPDES Discharge Limits
Compliance monitoring will be implemented to ensure that treated ground-water discharge requirements are satisfied. The program for confirming compliance will be consistent with specifications stipulated in the TPDES permit. Should compliance sampling indicate that contaminant levels in treated ground water exceed applicable discharge limitations, modifications to the existing treatment program will be developed. These modification may include additional GAC capacity or tertiary GAC treatment, upgrades to promote air stripper efficiency, or stimulation of pre-stripper volatilization via venturi agitation or similar devices. Appropriate measures will be developed to ensure Remedial Work Element II is in compliance with all discharge requirements.

5. <u>Exceedance of Air Stripper Off-Gas Limits</u>
Compliance monitoring will be implemented to ensure that air discharge requirements are satisfied. The program for confirming compliance will be consistent with specifications stipulated in the DPNR Air Pollution Control permit. Should compliance samples indicate that emissions of air stripper off-gas exceed applicable limitations, modifications to the existing treatment program will be developed. These modification may include treatment of a portion of the air stripper off-gas by routing it through the Remedial Work Element I catalytic oxidizer, adding vapor GAC treatment, or reducing ground-water extraction rates. Appropriate measures will be developed to ensure Remedial Work Element II is in compliance with all discharge requirements.

If any of the above concerns develop during the course of the SCP, EPA/DPNR will be notified and included in discussions related to evaluation and selection of alternative programs. As discussed above, many of the contingency issues are predicated on the collection of site monitoring and compliance for ground-water quality, ground-water elevation, water discharge concentrations, etc. Section 6.2 summarizes the compliance monitoring program that will be implemented as part of the Esso SCP.

SECTION 6.0

SAMPLING, ANALYSIS, AND MONITORING PLAN

Per Section VI, C3. of the UAO, a Sampling and Analysis and Monitoring Plan (SAMP) is required for the testing and monitoring to be performed during the Remedial Action phase. Specifically, sampling will be conducted as part of implementing the: 1) Initial Testing Program (ITP) Plan for the start-up of the SVE and Ground-Water Treatment systems; 2) Compliance Monitoring per the requirements established by the DPNR Air Pollution Control Permits and Territorial Pollutant Discharge Elimination System (TPDES) Permit; 3) Performance Monitoring; and 4) Post-Remediation Monitoring. The following sections discuss the types of samples (i.e., vapor, water, and soils) that will be collected in conjunction with each sampling program and the associated laboratory analytical methods. Refer to the ITP Plan (Appendix C) for details regarding sampling frequency, additional monitoring parameters, and a discussion of how the data will be used to evaluate the performance of the soil and ground-water treatment systems.

6.1 Initial Testing Program (ITP)

The Initial Testing Program (ITP) will be performed during the first four months of remedial activities to evaluate the performance and effectiveness of Remedial Work Element I and II. Sampling and monitoring activities performed as part of the ITP (see Appendix C for additional information) will satisfy all requirements stipulated by the DPNR Air Pollution Control and TPDES Permits (see Appendix D). Sampling and monitoring activities performed as part of the ITP will also provide comprehensive information for preparation of an accurate assessment of remedial system operation. The ITP results, specifically assessing the effectiveness of Remedial Work Elements I and II, will be submitted to the EPA/DPNR with the Remedial Construction Report (Section 6.6.1).

Sampling associated with the monitoring of Remedial Work Element I (SVE system) will include:

- Field measurements of total volatile organic compounds (VOCs), using a photoionization detector (PID), at each individual vapor extraction well and for the Vapor-Phase Treatment system (i.e., influent and off-gas samples from the catalytic oxidizer).
- Field measurements of carbon dioxide (CO_2) and oxygen (O_2) at each individual vapor extraction well and for the Vapor-Phase Treatment system.
- Field measurements of carbon monoxide (CO) and oxygen (O_2) for the Vapor-Phase Treatment system.
- Collection of vacuum and air velocity measurements at individual vapor extraction wells.
- Collection of tedlar bag vapor samples from individual vapor extraction wells and the Vapor-Phase Treatment system for laboratory analysis of VOC concentrations via EPA Method TO-14.

Table 6-1 provides a complete list of sampling/monitoring which will be performed in conjunction with Remedial Work Element I as part of the ITP. Additional details are provided in the ITP Plan (Appendix C).

Sampling/monitoring activities planned in association with the monitoring of Remedial Work Element II (Ground-Water Extraction/Treatment system) will include:

- Collection of ground-water quality samples from the system influent and effluent for laboratory analysis of VOCs by EPA Method 8240A, total petroleum hydrocarbons (TPH) by EPA Method 8015A, lead by EPA Method 7421, hardness (EPA Method 130.2), and iron (EPA Method 6010B).
- Collection of ground-water quality samples from individual extraction/treatment system wells for laboratory analysis of VOCs by EPA Method 8240A and total petroleum hydrocarbons (TPH) by EPA Method 8015A.
- Collection of ground-water quality samples at selected wells located downgradient of the impacted soil areas (SW-1, SW-3, SW-8, SW-9, SW-10) for laboratory analysis of VOCs (EPA Method 8240A) and TPH (EPA Method 8015A).

- Field measurements of dissolved oxygen (DO) concentration in ground-water quality samples from the eight ground-water recovery wells to determine the potential for natural biodegradation.

- Collection of ground-water elevation data from all monitoring wells on the Esso Service Station, as well as off-site wells CHT-3, MW-10, MW-10D, CHT-7D, MW-9, MW-9S, and CHT-2, on a weekly basis (for a total duration of one year).

- Continuous water level measurements in one shallow well (MW-8) and one deep well (DMW-1) pair.

Table 6-2 provides a complete list of sampling/monitoring which will be performed in conjunction with Remedial Work Element II as part of the ITP. Additional details are provided in the ITP Plan (Appendix C).

Data collected in conjunction with the ITP will be used to calculate the removal of petroleum mass from the subsurface, mass removal trends, vacuum radii of influence for SVE/bioventing wells, and Remedial Work Element I system effectiveness. The Remedial Construction Report will include vapor and ground-water capture zone maps; petroleum mass removal calculations, treatment efficiency data (vapor and ground water), ground-water table contour maps, and ground-water isoconcentration maps (BTEX, CVOCs, and TPH). These data will be evaluated with respect to potential achievement of the Performance Standards as established in the ROD and Section 5.0 of this report.

6.2 Compliance Monitoring

Sampling and monitoring conducted under the ITP Plan will satisfy all requirements stipulated by the DPNR Air Pollution Control and TPDES Permits (see Appendix D). After completion of the ITP, compliance monitoring will continue to be performed in accordance with the provisions of the Air Pollution Control and TPDES Permits.

Vapor discharges from the Vapor-Phase Treatment System will initially be regulated under an "Authority to Construct" Permit # STT-755-B-98 issued by DPNR Air Pollution

Control. This permit is currently undergoing finalization with DPNR. Sampling/monitoring associated with compliance monitoring of the vapor extraction system, summarized in Table 6-3, will include field monitoring of Vapor-Phase Extraction system influent and effluent for VOCs, monitoring system effluent for CO/O_2, and collecting vapor samples for laboratory analysis via EPA Method TO-14 for target analytes identified in the Air Pollution Control Permit.

During implementation of Remedial Work Element I, the catalytic oxidizer will be operated via control logic and continuously monitored. Should operating temperatures drop below the manufacturer's specifications (resulting in less effective destruction of contaminants), the control logic will be programmed to deactivate the remedial system. A detailed discussion of system control logic is presented in Section 4.0.

Vapor discharges from the ground-water remedial system will be regulated under the DPNR "Authority to Construct" Air Pollution Control Permit # STT-755-A-98. This permit is currently undergoing finalization with DPNR. Compliance sampling/monitoring associated with the Ground-Water Treatment system, summarized in Table 6-3, will consist of influent and effluent samples water samples from the air stripper which will be analyzed for target compounds identified in the Air Pollution Control Permit. The analytical data will be used to calculate total contaminant mass discharged by the air stripper.

Treated aqueous-phase discharges from the ground-water remedial system (i.e., post-carbon treatment) will be regulated under TPDES Permit # VI00040703 issued by DPNR (see Appendix D). Per the permit, compliance sampling/monitoring associated with the TPDES permit, summarized in Table 6-3, will include effluent sampling of BTX, TPH, TOC, TSS, lead, and pH (see Table 6-3 for analytical methods and frequencies).

6.3 Performance Monitoring

6.3.1 Remedial Work Element I

Following approval of the ITP, and EPA's determination that Remedial Work Element I is operating as designed, performance monitoring will be initiated. Sampling/monitoring data which will be collected during Remedial Work Element I Performance Monitoring, summarized in Table 6-4, will include 1) measurements of vacuum at individual SVE wells, and induced vacuum at VMPs, 2) field measurement of VOC and CO_2/O_2/methane concentrations at individual extraction wells and VMPs, 3) measurement of flow velocity at individual SVE wells (to calculate air flow rates), and 4) vapor sampling of individual SVE/bioventing extraction wells for laboratory analysis (via EPA Method TO-14). These data, in combination with system data collected in conjunction with compliance monitoring, will be used to calculate the removal of petroleum mass from the subsurface, mass removal trends, vacuum radii of influence for SVE/bioventing wells, and Remedial Work Element I system effectiveness.

Once site vapor data indicate that residual-phase hydrocarbon concentrations in vadose zone soils have reached an asymptote, confirmation soil sampling will be implemented adjacent to the north oil/water separator and the gasoline dispenser island to demonstrate that residual mass in soils will no longer act as a source of ground-water contamination above applicable MCLs. Soil confirmation samples will be analyzed for VOCs by EPA Method 8240, polycyclic aromatic hydrocarbons by EPA Method 8310, and TPH (e.g., gasoline and diesel range organics) by Gas Chromatography, EPA Method 8015A. Soil sampling protocol will be conducted consistently with the approved Supplemental Remedial Design Work Plan. Termination of soil remedial efforts will be based upon compliance with soil screening levels (SSLs) listed in the ROD and/or the observation of asymptotic conditions after the implementation of the Remedial Work Element I Contingency Measures (see Section 5.2)

6.3.2 Remedial Work Element II

Following approval of the ITP, and EPA's determination that Remedial Work Element II is operating as designed, performance monitoring will be initiated. Sampling/monitoring data which will be collected during Remedial Work Element II Performance Monitoring, summarized in Table 6-3, will include 1) liquid-level measurements at on-site wells and selected off-site wells (see Table 6-3), 2) field measurement of dissolved O_2 concentrations at individual extraction wells, 3) measurement of total gallons pumped from individual extraction wells, 4) ground-water quality sampling for water hardness and total iron from individual extraction wells, and 4) ground-water quality sampling of individual extraction wells and select monitoring wells on a regular basis for laboratory analysis of VOCs and TPH (see Table 6-4 for analytical methods and frequencies). These data, in combination with system data collected in conjunction with compliance monitoring, will be used to calculate the removal of petroleum mass from the subsurface, mass removal trends, hydraulic radii of influence for ground-water extraction wells, and Remedial Work Element II system effectiveness.

Data from the Performance Monitoring will be compared with the site-specific Performance Standards (see Section 5.3) to monitor system effectiveness. Termination of ground-water remedial efforts in the shallow bedrock aquifer beneath and downgradient of the Facility will be based upon compliance with Federal MCLs and/or the observation asymptotic concentrations after the implementation of the Remedial Work Element II Contingency Measures (see Section 5.4).

6.4 Post-Remediation Monitoring

Upon EPA's certification of completion of the Remedial Action and O&M Report, the Post-Remediation Monitoring (PRM) Plan will commence. Under the PRM Plan, confirmatory ground-water quality samples will be collected from all on-site wells, and previously sampled off-site wells (CHT-3, MW-10, MW-10D, CHT-7D, MW-9, MW-9S, CHT-2, and CHT-4) on an annual basis for a period of 3 years. PRM Plan sampling analytical methods and frequencies are summarized in Table 6-5.

6.5 Quality Assurance

To the extent appropriate, all sampling will be performed in accordance with the Region II CERCLA Quality Assurance Manual, Revision I, EPA II, dated October 1989, and the US EPA approved Quality Assurance Project Plan for the Tutu Service Station Investigation (Geraghty & Miller, Inc., 1992). Analytical services will be provided by Lancaster Laboratories, Inc. (LLI; Lancaster, Pennsylvania), a contract lab program (CLP)-certified laboratory, which will provide full CLP data packages.

Field Quality Control (QC) samples associated with collection of target compounds list (TCL) VOC ground-water samples will consist of travel blanks submitted at a rate of one per sample cooler. Completed chain-of-custody forms will be sealed in plastic bags and placed in each sample cooler. All samples will be preserved with ice sealed in plastic bags and shipped by overnight courier to LLI.

All non-disposable sampling equipment will be decontaminated as follows:

- manual scrub with non-phosphate soap and potable water using a brush;
- thorough rinse with potable water;
- rinse with pesticide-grade acetone;

- triple rinse with distilled water; and
- air dry.

Pumps used to purge wells prior to sampling will be decontaminated between each use. Submersible pumps will be washed on the exterior with a non-phosphate soap and tap water solution and rinsed with tap water. After rinsing, 4 to 5 gallons of tap water will be pumped through the pump discharge lines. All purge water and equipment decontamination fluids will be staged on-site and treated through the Ground-Water Treatment system.

Portable instruments will be used for field measurement of vapor samples collected to monitor operation of the SVE and bioventing systems during the course of the Remedial Action. A PID will be used to measured with total VOCs and a field gas meter will be used to measure carbon dioxide, oxygen, and methane at individual SVE/Bioventing extraction wells. Field equipment will be calibrated as recommended by the manufacturer. Calibration results will be recorded in a bound log book.

6.6 Reporting

6.6.1 ITP Results

Within 60 days of completing the ITP, the Remedial Construction Report will be submitted to EPA. The report will present the findings of the ITP, as well as a description of the construction work performed, documentation of any changes from the approved design, "As-built" drawings, and all laboratory data.

The Remedial Construction Report will include, at a minimum, vapor and ground-water capture zone maps; petroleum mass removal calculations, treatment efficiency data (vapor and ground water), ground-water table contour maps, and ground-water isoconcentration maps

(BTEX, CVOCs, and TPH). These data will be evaluated with respect to potential achievement of the Performance Standards as established in the ROD and Section 5.0 of this report.

6.6.2 Compliance Monitoring

Compliance monitoring reporting requirements are specified in the appropriate DPNR permits. Monthly summaries of Air Pollution Control Permit monitoring data will be submitted to DPNR. Monthly Discharge Monitoring Reports (DMR) will be submitted to EPA/DPNR for TPDES permit compliance. All required permit records and monitoring information will be entered in a permanently bound log book, maintained at the Esso Tutu Service Station for a minimum of 5 years after data entry. Permit records will be made available to DPNR upon request.

6.6.3 Performance Monitoring

Following approval of the ITP, and EPA's determination that Remedial Work Elements I and II are operating as designed, performance monitoring will be initiated. Sampling/monitoring data which will be collected during Remedial Work Element I Performance Monitoring are summarized in Table 6-3. Data collected during the SVE and bioventing monitoring program will be used to calculate the removal of petroleum mass from the subsurface, mass removal trends, vacuum radii of influence for SVE/bioventing wells, and SVE/bioventing system effectiveness. System performance update reports will be issued to EPA/DPNR every six months.

Results from ground-water samples and monitoring collected in association with Remedial Work Element II Performance Monitoring are summarized in Table 6-3. Data collected will be used to calculate the removal of petroleum mass from the subsurface, mass removal trends, hydraulic radii of influence for ground-water extraction wells, and Remedial

Work Element II system effectiveness. Update reports, which will include ground-water table contour maps and isoconcentration maps for BTEX, CVOCs, and TPH, will be issued to EPA/DPNR every six months. Brief status reports transmitting raw performance data will be submitted to EPA on a monthly basis.

6.6.4 Post-Remediation Monitoring

Results from soil samples collected in association with the Remedial Work Element I confirmation sampling program will be compiled, interpreted, and presented in a report which will be submitted to EPA/DPNR. If the data indicate that soil contaminant concentrations achieved via SVE/bioventing have been reduced to less than the designated SSLs, the report will include a request to terminate Remedial Work Element I. If the soil contaminant concentrations remain above the SSLs, Remedial Work Element I Contingency Measures (see Section 5.2) will be invoked.

Results from ground-water samples collected in association with the Remedial Work Element II confirmation sampling program will be compiled, interpreted, and presented in reports submitted to EPA/DPNR on an annual basis for a period of 3 years. The reports, which will include ground-water table contour maps and isoconcentration maps (BTEX, CVOCs, and TPH), will be used to document that ground-water contaminant levels have remained within the Performance Standards specified in the ROD and Section 5.3 of this report.

SECTION 7.0

Operations and Maintenance

A preliminary Operation and Maintenance (O&M) Manual is attached as Appendix E. This O&M Manual discusses routine operations and maintenance of the vapor-phase and ground-water extraction/treatment systems, potential operating problems including common remedies, and a discussion of the documentation/record keeping procedures. A local contractor will be selected to operate the treatment system, but at the present time, one has not been identified.

7.1 Start-up

Monitoring activities associated with the start-up and initial testing of the SVE and Ground-water Extraction/Treatment systems are detailed in the Initial Testing Program (ITP) presented in Appendix C. Implementation of the ITP will start within 10 days of completion of construction of the Treatment systems, and monitoring activities will extend over a period of 4 months. The purpose of the ITP is to document that Remedial Elements I and II are functioning as designed. An inspection will be performed by EPA or their representative during the performance of the ITP to develop a punch list of deficiencies, if any. Within 60 days of completing the monitoring associated with the ITP, the Remedial Construction Report will be submitted to EPA.

7.2 Site Management

The Esso Service Station is open on a daily basis and the hours of operation are from approximately 7:00 a.m. to 11:00 p.m. The treatment system will be housed in a land sea container located within a fenced area at the northwest corner of the service station property.

The gate to the fenced enclosure will remain locked at all times. The treatment system wells are finished below grade and secured in 2 foot by 2 foot well vaults with lids that are bolted down. All piping connecting the wells to the treatment system will be installed below grade in trenches.

In the event of system failure, the telephone dial-out system is activated to notify the operator of a system shutdown. Several of the alarms do not automatically reset and require the operator to depress the reset button to restart the system. The operator will respond to any alarm within 24 hours. A key to the fenced enclosure will be maintained at the Esso Terminal adjacent to the St. Thomas airport, by the O & M contractor, and by the FES Project Manager in Exton, Pennsylvania.

Waste disposal activities will consist of disposing of phase-separated hydrocarbons which may be recovered as part of operating the ground-water extraction/treatment system. A waste removal firm will be subcontracted by Esso to dispose of wastes generated as a result of operating the treatment system in accordance with all applicable territory and Federal requirements, including RCRA Regulations.

7.3 Operation Quality Assurance Project Plan

Sampling activities will include the collection of vapor samples associated with monitoring the SVE system and ground-water samples from recovery monitoring wells. Figures 7-1 and 7-2 depict the sampling locations for these vapor and aqueous samples. To the extent applicable, sampling protocols will be in accordance with the US EPA approved Supplemental Remedial Design Work Plan (SRDWP) (FES, 1998) and the Quality Assurance Project Plan (QAPP) for the Tutu Service Station Investigation (Geraghty & Miller, 1992). Refer to Section C.3 Quality Assurance, of the ITP located in Appendix C for a detailed discussion of sampling and analytical methods.

7.4 Operation Health and Safety Contingency Plan

The previously referenced O&M Plan provides Health and Safety protocols as a supplement to the site-specific Health and Safety Contingency Plan (HSCP) (Appendix F). The plan details safety, accident and fire protection standards to be used during the course of the project. Spill response equipment consisting of sorbent pads and booms will be maintained on site to facilitate rapid respond to any release. No smoking will be permitted in the fenced enclosure and fire extinguishers for use on small fires will be available in the trailer housing the treatment system.

The O&M subcontractor, as well as an appropriate Esso and FES representative will be on-site during the start-up of the treatment system and receive training with respect to precautions to take when working with and around the various components of the treatment system. The site-specific HSCP provides a list of local emergency telephone numbers which would be contacted in the event of an emergency and map showing the route to the nearest hospital.

SECTION 8.0

CONSTRUCTION QUALITY ASSURANCE PROJECT PLAN

The Construction Quality Assurance Project Plan (QAPP) will provide quality assurance/quality control during the remedial system construction phase. The Construction QAPP will be directed by a Professional Engineer licensed in the Virgin Islands (M. xxx xxx, Independent Equipment Corporation) and implemented by the Site Engineer/Scientist and/or a qualified designee) who will be on site during all remedial system construction activities.

The Site Engineer/Scientist (Chad Stevens, Esso/Robert Zei, FES) will be authorized to stop all activities which are not in compliance with the QAPP, applicable environmental and contract requirements, or any activities which endanger the health and safety of construction personnel and surrounding residents. The Site Engineer/Scientist will be responsible for remedial system construction quality assurance inspections and testing as discussed below in Sections 8.1 and 8.2.

8.1 Inspection and Certification

The Site Engineer/Scientist will review documentation provided by the on-site contractor(s) to affirm that all construction materials used at the site meet industry and performance guidelines as required in the engineering construction Technical Specifications package prepared by Hill & Bell (dated 22 July 1998, see Appendix A). The Site Engineer/Scientist will conduct daily inspections of all installed piping and trenches to assure compliance with installation specifications established in the engineering construction design drawings. Situations of non-compliance will be documented in the daily log (see Section 8.1.1) and to the appropriate contractor(s). Additional work will not proceed until the non-compliance is corrected by the contractor(s). The Site Engineer/Scientist will also supervise all on-site quality testing (see Section 8.3).

The remedial treatment system will be assembled off site by Independent Equipment Corporation (IEC) of Raritan, New Jersey. A licensed PE and project engineers (Richard Tobia, Abraham Platt, Paul Fischer) on the IEC project team, and qualified technicians from IEC will inspect and test each component (see Section 8.3) to ensure it meets manufacturer and industry standards. A representative from FES (Robert Zei) will also inspect the system for proper operation before shipment to the facility. A member of the IEC project team (to be determined at a later date) and a representative from FES (Robert Zei) will reinspect the remedial system after it is installed at the Facility. IEC will provide written certification of the successful completion of inspection and testing of system components to the Site Engineer/Scientist.

During remedial system construction, modifications of the original remedial system design may occur. These deviations may include changes such as minor relocations of piping or trenches due to accessibility constraints, changes in piping configuration which improve ease of installation or access, or other small changes of a similar nature. Modifications from the original remedial system design will be limited to changes which do not affect ultimate system operation or performance; all changes are subject to the approval of the Site Engineer/Scientist. Any modifications which are likely to affect system operation or performance will require full review and approval by EPA and DPNR before implementation.

A Professional Engineer licensed by the Virgin Islands (M. xxx, xxx) will review all documents associated with the Construction QAPP including daily logs, as-built drawings, testing results, and contractor's certifications. After review and approval of these documents, and inspection and testing of the remedial system, the Professional Engineer will certify that:

1) the Remedial Construction Work has been completed in full satisfaction of the requirements of the 5 August 1996 ROD, the Order, and all plans and specifications developed thereunder, including the Construction QAPP, and

2) the SVE and Ground-Water Extraction/Treatment systems are operating in accordance with approved design and performance criteria.

This Certification of Work will be submitted to EPA/DPNR as part of the Remedial Construction Report.

8.1.1 Daily Logging and Measurements

A daily construction log will be completed and signed by the Site Engineer/Scientist. The daily logs will provide detailed descriptions of all construction activities including:

a) contractors and personnel on site
b) work performed
c) health and safety issues
d) community relations
e) air monitoring
f) daily inspection results
g) soils quantities excavated
h) waste stockpiling and/or disposal
i) testing performed and resultant data

The daily log will also include the dimensions of piping and trenching installed, surveying measurements, and an inventory of materials utilized. Information will be cross-referenced and indicated on a set of engineering construction drawings where appropriate.

Photodocumentation of remedial construction activities will also be prepared on a daily basis. All excavated trenches, trenches with installed piping, well vaults, system pulling stations, piping connections, treatment enclosure, and treatment system components will be photographed with appropriate scaling. Photographs will be recorded in the daily log and photo locations will be keyed on the "as-built" drawings (see below). Select photographs will be included in the Remedial System Construction Report.

8.1.2 "As-Built Drawings" and Logs

During remedial construction, a dedicated set of engineering construction design drawings will be used on site for recording minor field changes modifications of the original remedial system design. All field changes will have received prior approval from the Site Engineer/Scientist before implementation. The Site Engineer/Scientist will initial and date all such changes on the dedicated engineering construction design drawings. The changes will also be recorded in the daily log (see Section 8.2.1), and photodocumented where appropriate.

The dedicated field construction drawings, daily logs, and photodocuments will be used to generate a set of "as-built" drawings upon completion of remedial system construction. The "as-built drawings" will be signed and stamped by a Professional Engineer licensed by the Virgin Islands (M. xxx, Hill & Bell Associates) and submitted as part of the Remedial Construction Report.

8.2 Testing of Materials, Construction, and Final System

The SVE and Ground-Water Treatment systems will be tested to assure proper performance and compliance with all applicable EPA and DPNR regulations. Equipment/materials testing will occur in four stages:

a) Remedial system assembly - The remedial treatment system will be assembled in New Jersey by IEC. A licensed PE and project engineers (Richard Tobia, Abraham Platt, Paul Fischer) on the IEC project team, and qualified technicians from IEC will inspect and test each component (see Section 8.3) to ensure it meets manufacturer and industry standards. A representative from FES (Robert Zei) will also inspect the system for proper operation before shipment to the facility. Each system component will be tested individually and/or in conjunction with other associated system components to assure proper performance of the system before final shipment to the Facility. The remedial system assembly contractor (IEC) will provide written certification of the successful completion of inspection and testing of system components to the Site Engineer/Scientist.

b) Well installation - The drilling subcontractor will provide well construction materials which meet all relevant industry standards to ensure proper well performance. Wells will be installed and developed according to the protocol presented in the Supplemental Remedial Design Work Plan (draft submittal to EPA/DPNR dated 14 August 1998). A Project Scientist from FES will supervise all well installation activities. The Project Scientist will maintain a detailed daily log which includes all pertinent descriptions, boring logs, measurements, and other data associated with the well installations.

c) Construction associated with remedial system trenching and piping - All materials used in association with remedial system trenching and piping installation will meet industry standards and performance guidelines required in the engineering construction Technical Specifications package prepared by Hill & Bell (dated 22 July 1998, see Appendix A). Installed piping and trenches will be measured/surveyed to assure conformity with installation specifications established in the engineering construction design drawings.

After installation, each vapor line segment (well to pull station, or pull station to pull station) will be vacuum- or air pressure-tested using standard field methods to ensure that adequate vacuum (or pressure) will be maintained. Each extraction line will be capped and subjected to an induced vacuum of 60 inches of water for a period of one hour. Extraction lines which do not maintain an induced vacuum of at least 58 inches of water will be reinstalled. Ground-water recovery, secondary containment, and pneumatic air line segments will be pressure-tested to 80 pounds per square inch (psi), and required to maintain at least 78 psi for one hour. Alternate methods of line testing, such as helium line leak detection, may be substituted with the approval of the Site Engineer/Scientist. Test results will be documented and approved by the Site Engineer/Scientist before the corresponding trench segment is backfilled.

d) On-site remedial treatment system installation - Qualified technicians from the remedial treatment construction contractor (IEC) will inspect and test all components of the remedial treatment system after shipment and on-site installation to ensure proper operation. Testing will include, but not be limited to, reviewing all faults, probes, safety switches, and logic controls for proper functioning; preliminary operation of all well pumps, transfer pumps, blowers, and motors for performance evaluation; preliminary operation of the air stripper and catalytic oxidizer to ensure proper operational temperatures, air flow, and air processing; and inspecting and testing the complete remedial system for leaks or other breaches of integrity.

The remedial system construction contractor (IEC) will provide written certification upon successful completion of inspection and testing of the installed remedial system. An accelerated sampling and monitoring compliance schedule (see Section 6.2) will be followed during system start-up to ensure that the remedial system operates within applicable EPA/DPNR regulations.

8.3 Construction Access Agreements

Well installation and associated trenching activities will be performed on the Four Winds property, located to the south and west of the site. An Access Agreement for these activities was granted by the property owners; a copy of the agreement is included as Appendix G. No properties or easements were acquired as part of the Remedial Action.

8.4 Method of Selection of Construction Contractor(s)

The Remedial Treatment System construction contractors (IEC) were selected based on prior experience with the proposed remedial technologies, ability to fabricate pre-packaged, "turn-key" remedial systems, adequate environmental insurance coverage, proper OSHA training and certification for all on-site workers, and previous Superfund experience.

The Remedial Construction trenching and piping installation phase of work is currently out to bid. Bids packages were sent to qualified construction firms included on Esso's preferred contractor list and additional local construction firms with equivalent credentials. Selection of the construction contractor(s) will be based on a review of the contractor's qualifications to perform the necessary work, previous experience with similar types of construction, equipment and labor availability, and reasonableness of construction schedule and costs. The successful bidder will be required to provide proof of adequate environmental insurance coverage and proper OSHA training and certification for all on-site personnel.

8.5 Final Cost Estimate and Schedule

A final construction cost estimate is included as Table 8-1. The total estimated cost of the remedial system construction and installation is $604,000. Please note that this cost estimate does not include expenditures associated with subsequent remedial system operation and monitoring.

A proposed construction implementation schedule is included as Table 8-2. The schedule indicates that off-site assembly of the remedial treatment system will be performed during September-October 1998, concurrent with the installation of on-site remedial system trenching and piping. Following shipment of the remedial treatment system in early November 1998, final on-site assembly and initial start-up and testing of the completed remedial system is anticipated for late November 1998.

TABLES

Table 2-1
Summary of Analytical Data
North Oil/Water Seperator (1993)
Esso Tutu Service Station
St. Thomas, USVI

Analytical Parameter	Units	SS-1 (9')	SS-3 (3')	SS-4 (3')	SS-5 (3')	SS-6 (5')	SS-7 (5')	SS-8 (7')	SS-9 (3')
Aromatic Hydrocarbons									
Benzene	(mg/Kg)	<1.6	0.88	<0.029	0.029	<0.006	0.16	0.27	<0.006
Toluene	(mg/Kg)	46	53	4.6	6.5	<0.006	33	51	<0.006
Ethylbenzene	(mg/Kg)	12	11	0.99	0.52	<0.006	1.7	11	<0.006
Total Xylenes	(mg/Kg)	80.4	77.4	24.2	29	<0.006	58	78	<0.006
Chlorinated Compounds									
Trichloroethene	(mg/Kg)	<1.6	0.26	<0.029	<0.029	<0.006	<0.029	0.045	<0.006
Tetrachloroethene	(mg/Kg)	<1.6	1.1	0.15	0.13	<0.006	0.52	1.5	<0.006
1,1-Dichloroethane	(mg/Kg)	<1.6	0.56	<0.029	<0.029	<0.006	0.031	0.07	<0.006
1,2-Dichloroethene	(mg/Kg)	<1.6	3.2	<0.029	0.032	<0.006	0.075	0.11	<0.006
1,1,1-Trichloroethane	(mg/Kg)	<1.6	<0.036	<0.029	<0.029	<0.006	0.044	0.058	<0.006
Base-Neutral Compounds									
1,2-Dichlorobenzene	(mg/Kg)	NA	2.8	0.84	<2	<0.38	<0.77	1.4	<0.4
Naphthalene	(mg/Kg)	NA	29	11	22	<0.38	19	23	<0.4
Fluorene	(mg/Kg)	NA	3.4	1.4	2.6	<0.38	1.4	1.6	<0.4
Phenanthrene	(mg/Kg)	NA	9.7	4.5	8.1	<0.38	4.3	6.1	<0.4
Anthracene	(mg/Kg)	NA	<2.4	0.92	<2	<0.38	<0.77	1.2	<0.4
Fluoranthene	(mg/Kg)	NA	3.1	1.2	2.4	<0.38	1.1	1.5	<0.4
Pyrene	(mg/Kg)	NA	15	6.5	9	<0.38	5.7	8	<0.4
Benzo (a) anthracene	(mg/Kg)	NA	5.8	2.3	4.3	<0.38	2.1	2.8	<0.4
Chrysene	(mg/Kg)	NA	5.1	2	3.6	<0.38	1.9	2.4	<0.4
Bis (2-ethylhexyl) phthalate	(mg/Kg)	NA	19	8.3	11	<0.38	6.7	9.2	<0.4
Di-n-octyl phthalate	(mg/Kg)	NA	<2.4	2	<2	<0.38	<0.77	<0.77	0.94
Benzo (b) fluoranthene	(mg/Kg)	NA	6.1	2	3.8	<0.38	2	2.5	<0.4
Benzo (a) pyrene	(mg/Kg)	NA	3.2	0.97	<2	<0.38	0.88	1.1	<0.4
Benzo (ghi) perylene	(mg/Kg)	NA	7.7	1.6	3.4	<0.38	1.4	1.9	<0.4
Petroleum Hydrocarbons									
Gasoline Range	(mg/Kg)	NA	5,000	3,000	3,000	<8	4,000	5,000	<8
Kerosene Range	(mg/Kg)	NA	<4,000	<1,000	<1,000	<8	<1,000	<1,000	<8
Diesel Range	(mg/Kg)	NA	<4,000	<1,000	<1,000	<8	<1,000	<1,000	<8

Notes:
1. NA = not analyzed
2. Volatile organic analysis conducted by EPA Method 8240; base neutrals analyzed by EPA Method 8270;
3. TPH analysis conducted by Method 8015 (GD-FID).
4. mg/Kg = Parts per million.

Table 2-2
Summary of Soil Analytical Data (1996)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Sample Designation	Date	Depth (feet)	Benzene (ug/Kg)	Toluene (ug/Kg)	Ethylbenzene (ug/Kg)	Total Xylenes (ug/Kg)	MTBE (ug/Kg)	Acetone (ug/Kg)	Methylene Chloride (ug/Kg)	Trichloro Ethene (ug/Kg)	Tetrachloro Ethene (ug/Kg)	trans-1,2 Dichloro Ethene (ug/Kg)	cis-1,2 Dichloro Ethene (ug/Kg)	1,1 Dichloro Ethene (ug/Kg)	1,1 Dichloro Ethane (ug/Kg)	1,2 Dichloro Ethane (ug/Kg)	2-Butanone (ug/Kg)	Total Organic Carbon (mg/Kg)	TPH DRO (mg/Kg)	TPH GRO (mg/Kg)
North Oil/Water Separator																				
B-1	9/17/96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B-2	9/18/96	5-8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,900	NA	NA
B-5	9/23/96	4-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2410	NA	NA
		6-8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		8-10	<5	<5	30	19 J	<5	45 J	<10	<5	<5	<10	<10	<10	<5	<10	<35	NA	<200*	700*
B-6	9/23/96	4-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3160	NA	NA
		8-10	4 J	<1	<1	6	33	<7	<2	<1	<1	<2	<2	<2	<1	<2	<7	NA	<200*	300 J*
B-7	9/23/96	4-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2830	NA	NA
		8-10	3 J	10	56	35	63	480	<2	<1	<1	<2	<2	<2	<1	<2	<8	NA	<9*	<9*
B-15	9/25/96	4-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2300	NA	NA
		6-8	<1	<1	<1	<1	<1	<8	12	<1	<1	<2	<2	<2	<1	<2	<8	NA	6 J	<200
		10-12	<6	<6	66	26 J	<6	<42	95	<6	<6	<12	<12	<12	<6	<12	<42	NA	1,600	2,000
B-18	9/25/96	4-8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2400	NA	NA
B-19	9/26/96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B-20	9/26/96	8-10	<1	1 J	<1	<1	30	45	120	<1	<1	<2	<2	<2	<1	<2	<8	NA	5 J	<200
B-16	9/25/96	4-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2100	NA	NA
		10-12	2 J	4 J	10	21	4 J	75	40	<1	<1	<2	<2	<2	<1	<2	14	NA	2,200	30,000
		14-16	<1	<1	<1	<1	<1	<9	13	<1	<1	<2	<2	<2	<1	<2	25	NA	5 J	2,000
B-17	9/25/96	10-12	<1	1 J	<1	<1	<1	37	81	<1	<1	<2	<2	<2	<1	<2	<8	NA	<5	<0.2
Delivery Line/Dispenser Island																				
B-3	9/20/96	2-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,000	NA	NA
		6-8	<1	<1	4 J	28	220	590	4 J	<1	<1	<2	<2	<2	<1	<2	<8	NA	15	4
		8-10	<5	<5	110	1,000	67	410	<11	<5	<5	<11	<11	<11	<5	<11	<37	NA	37	7
		10-12	<5	<5	90	820	42	390	<11	<5	<5	<11	<11	<11	<5	<11	<38	NA	NA	NA
B-4	9/20/96	4-6	<1	<1	<1	<1	30	360	5 J	<1	<1	<2	<2	<2	<1	<2	<8	1,200	<4	<0.2
B-8	9/24/96	1-3	<1	4 J	1 J	<1	33	210	<2	<1	<1	<2	<2	<2	<1	<2	51	NA	<5	2
		4-6	<1	<1	<1	<1	<1	31	<2	<1	<1	<2	<2	<2	<1	<2	9 J	NA	16	2
B-9	9/24/96	6-8	<1	<1	<1	<1	<1	17 J	<2	<1	<1	<2	<2	<2	<1	<2	<8	NA	6 J	<0.2
B-10	9/24/96	4-6	<1	<1	<1	<1	<1	20 J	<2	<1	<1	<2	<2	<2	<1	<2	<7	NA	<4	<0.1 J
B-11	9/24/96	2-4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,300	NA	NA
		4-6	<1	<1	2 J	<1	1,000	87	<2	<1	<1	<2	<2	<2	<1	<2	27	NA	5 J	0.8 J
		8-10	<1	<1	<1	<1	49	110	<2	<1	<1	<2	<2	<2	<1	<2	14	NA	<4	<0.2
B-12	9/24/96	4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5200	NA	NA
		6-8	<1	3 J	<1	<1	5 J	450	<2	<1	<1	<2	<2	<2	<1	<2	130	NA	20	0.3 J
B-13	9/24/96	4-6	<1	4 J	10	11	170	210	<2	<1	<1	<2	<2	<2	<1	<2	39	NA	8 J	2
		6-8	<1	3 J	33	120	120	150	<2	<1	<1	<2	<2	<2	<1	<2	32	NA	10	7
B-14	9/24/96	6-8	<1	<1	3 J	<1	81	240	4 J	<1	<1	<2	<2	<2	<1	<2	21	NA	6 J	0.8 J
		8-10	6	7	280	24	48	<8	<2	<1	<1	<2	<2	<2	<1	<2	<8	NA	2,100	70
		10-12	280 J	<150	3,600	690 J	1,300	<1000	440 J	<150	<150	<300	<300	<300	<150	<300	<1000	NA	2,000	110
B-21	9/27/96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B-22	9/27/96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B-23	9/30/96	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B-24	9/30/96	7-9	<1	<1	8	<1	57	250	<2	<1	<1	<2	<2	<2	<1	<2	<8	NA	14 J	0.06 J
		9-11	280 J	<150	23,000	240 J	440 J	<1000	<290	<150	<150	<290	<290	<290	<150	<290	<1000	NA	810	150

Forensic Environmental Services, Inc.

Table 2-2
Summary of Soil Analytical Data (1996)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Sample Designation	Date	Sample Interval (feet)	Naphthalene (ug/Kg)	Acenaphthylene (ug/Kg)	Acenaphthene (ug/Kg)	Fluorene (ug/Kg)	Phenathrene (ug/Kg)	Anthracene (ug/Kg)	Fluoranthene (ug/Kg)	Pyrene (ug/Kg)	Benzo (a) anthracene (ug/Kg)	Chrysene (ug/Kg)	Benzo (b) fluoranthene (ug/Kg)	Benzo (k) fluoranthene (ug/Kg)	Benzo (a) pyrene (ug/Kg)	Dibenzo (a,h) anthracene (ug/Kg)	Benzo (g,h,i) perylene (ug/Kg)	Indeno (1,2,3-cd) pyrene (ug/Kg)
North Oil/Water Separator																		
B-5	9/23/96	8-10	<590	<490	<1800	840 J	580 J	291 J	<16	525 J	130	140 J	<7.3	<6.8	<20	<60	330	57 J
B-6	9/23/96	8-10	318 J	<98	<360	625 J	740	400	<7.8	<41	102	130	103	<3.4	71.9	<30	159	21
B-7	9/23/96	8-10	5660 J	<560	<2100	<1100	2400	1290 J	<18	1240	517	540	286	<110	258	<69	530	105 J
B-15	9/25/96	10-12	1030	<120	<430	230 J	370	172 J	<1.9	213	61.4	68	40.3	12.9	36.2	<26	84	13.3 J
B-16	9/25/96	10-12	<140	<120	<440	53 J	46 J	14.9 J	<4.8	<25	<3.8	<11	<2.1	<34	9	40.6	37	<16
		14-16	<72	<60	<220	<13	<21	<2.1	<240	<50	<9.7	<22	<4.3	<4.1	<12	235	<120	<33
Delivery Line/Dispenser Island																		
B-3	9/20/96	8-10	<63	<52	<190	<12	<18	<1.8	<0.83	<4.4	<0.67	<1.9	<0.37	<0.36	129	<140	<280	74
B-4	9/20/96	4-6	<66	<55	<200	<12	<19	<1.9	<0.87	<4.6	<0.7	2.3 J	<0.39	<0.38	<1.1	<3.3	<11	<3
B-14	9/24/96	8-10	9600 J	<1100	<4200	2820 J	4,100	1700 J	<18	1310 J	447	480 J	470	98.1 J	270	<69	500	117 J
		10-12	13400 J	<1200	<4300	4240 J	6,200	2590 J	<19	2,000	680	790	730	149 J	420	149 J	730	147 J
B-24	9/30/96	9-11	2120	<57	<210	488 J	560	220	<89	<4.8	31.9	50	49.4	<0.79	24	<15	50	9.1 J

Notes:
1. Total organic carbon by EPA Method 415.1 modified.
2. TCL Volatiles by EPA Method 8240
3. PAH's by EPA Method 8310.
4. BTEX by EPA Method 8020A.
5. * = Samples were analyzed for Total Petroleum Hydrocarbons by GC-FID Method 8015B modified.
6. J = Estimated concentration.
7. NA = Not Analyzed.
8. A "<" indicates the method detection limit used for that particular compound.
9. ug/Kg = Parts per billion.
10. mg/Kg = parts per million.
11. DRO = Diesel Range Organics.
12. GRO = Gasoline Range Organics.

Table 2-3
Summary of Site Ground-Water Quality Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Analytical Parameter	Units	SW-1		SW-2			SW-3			SW-7			SW-8		DW-1		CHT-2				CHT-3			
		4/5/94	9/28/96	4/5/94	6/22/94	9/28/96	4/5/94	6/23/94	10/4/96	4/5/94	6/23/94	10/5/96	10/3/96	10/3/963 D	4/7/94	6/3/94	2/27/92	4/11/94	9/8/96	10/4/96	2/27/92	11/17/93	4/11/94	6/1/94
Volatile Organic Compounds																								
Benzene	(ug/L)	3,700	3,100	1,400	550 J	220	12,000	10,000 J	10,000	160	99 J	110	2 J	1 J	<5	<10	<50	5	11	15	26,000	2,200	1,900	1,700
Toluene	(ug/L)	1,800	680	1,800	360 J	140	3,400	3,200 J	96	16	<100	<10	<2	<2	<5	<10	<50	<5	<2	<2	38,000	1,600	<50	180
Ethylbenzene	(ug/L)	2,000	1,800	1,000	<1000	18 J	2,200	4,100 J	2,100	110	<100	78	48	45	<5	<10	120	<5	3 J	4 J	2,400	<25	1,500	1,800
Total Xylenes	(ug/L)	8,100	3,000	4,000	1,800 J	130	10,300	22,000 J	8,000	171	82	36	61	59	<5	<10	<50	<5	1 J	4 J	38,000	1,500	1,153	2,000
MTBE	(ug/L)	42,000	14,000	52,000	35,000 J	2400	110,000	89,000 J	100,000	1600	1,500 J	2,700	150	<2	19	16 J	NA	870	110	130	6,200	13,000	15,000	13,000
TCE	(ug/L)	<250*	<10	<250*	<1000*	8 J	<250*	<1000*	<10	<5	<100	<5	<1	<1	15	10 J	<50	<5	<1	<5	<1,000	<25	<50*	<100*
PCE	(ug/L)	<250*	<10	<250*	<1000*	12 J	<250*	<1000*	<10	<5	<100	<5	<1	<1	62	42 J	<50	<5	<1	<5	<1,000	<25	<50*	<100*
trans 1,2 DCE	(ug/L)	NA	<20	NA		<10	NA		<20	NA		<10	<2	<2			NA	NA	<2	<10	NA	<25	NA	
cis 1,2 DCE	(ug/L)	NA	<20	NA		32	NA		<20	NA		<10	<2	<2			NA	NA	<2	<10	NA	NA	NA	
1,2 DCE (total)	(ug/L)	<250*	NA	<250*	<1000*	NA	<250*	<1000*	<20	<5	<100	<10	NA	NA	130	92 J	NA	6	NA	<10	NA	NA	<50*	<100*
Vinyl Chloride	(ug/L)	<500*	NA	<500*	<1000*	NA	<500*	<1000*	<10	<10	<100	<5	NA	NA	<10	<10	<100	<10	NA	<5	<1,000	<25	<100*	<100*
Acetone	(ug/L)	NA	<60	NA		<30	NA		<60	NA		<30	<6	<6			NA	NA	11 J	<6	NA	NA	NA	
Methylene Chloride	(ug/L)	NA	34 J	NA		12 J	NA		28 J	NA		10 J	<2	<2			<50	NA	<2	<2	<1,000	<25	NA	
Total Petroleum Hydrocarbons																								
Gasoline Range	(mg/L)	120	NA	25	NA	NA	310	NA	NA	6	NA	NA	NA	NA	<0.4	NA	NA	<0.4	NA	NA	NA	NA	69	NA
Kerosene Range	(mg/L)	<4	NA	<4	NA	NA	<40	NA	NA	<4	NA	NA	NA	NA	<0.4	NA	NA	<0.4	NA	NA	NA	NA	<0.4	NA
Diesel/#2 Range	(mg/L)	<4	NA	<4	NA	NA	<40	NA	NA	<4	NA	NA	NA	NA	<0.4	NA	NA	<0.4	NA	NA	NA	NA	<0.4	NA
Total Petroleum Hydrocarbons	(mg/L)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Polynuclear Aromatic Hydrocarbons																								
Naphthalene	(ug/L)	60	NA	<100	<10	NA	1,300	1,000 J	NA	60	96 J	NA	NA	NA	<10	<10	65	<10	NA	NA	NA	NA	260	310
Fluorene	(ug/L)	<4	NA	<2	<10	NA	40	40 J	NA	<2	4 J	NA	NA	NA	<2	<10	<10	<2	NA	NA	NA	NA	3	6 J
Phenathrene	(ug/L)	4	NA	<2	<10	NA	40	32 J	NA	4	3 J	NA	NA	NA	<2	<10	<10	<2	NA	NA	NA	NA	2	4 J
Anthracene	(ug/L)	1	NA	<1	<10	NA	9	<50	NA	<2	<10	NA	NA	NA	<1	<10	<10	<1	NA	NA	NA	NA	<1	<20
Pyrene	(ug/L)	3	NA	<2	<10	NA	7	8 J	NA	3	2 J	NA	NA	NA	<2	<10	<10	<2	NA	NA	NA	NA	<2	<20
Chrysene	(ug/L)	1	NA	<1	<10	NA	<4	9 J	NA	1	<10	NA	NA	NA	<1	<10	<10	<1	NA	NA	NA	NA	<1	<20
Benzo(a) pyrene	(ug/L)	0.3	NA	<0.2	<10	NA	0.7	<50	NA	0.3	<10	NA	NA	NA	<0.2	<10	<10	<0.2	NA	NA	NA	NA	<0.2	<20
Benzo (g,h,l) perylene	(ug/L)	1.4	NA	<0.5	<10	NA	3	<50	NA	1.4	<10	NA	NA	NA	<0.5	<10	<10	<0.5	NA	NA	NA	NA	<0.5	<20
Benzo (b) fluoranthrene	(ug/L)	<0.6	NA	<0.2	<10	NA	2.1	<50	NA	0.5	<10	NA	NA	NA	<0.2	<10	<10	<0.2	NA	NA	NA	NA	<0.2	<20
General Water Chemistry																								
Total Suspended Solids	(mg/L)	120	NA	NA	284	NA	2,820	324	NA	260	783	NA	NA	NA	18	<10	NA	NA	NA	NA	NA	NA	NA	12300
Carbon Dioxide	(mg/L)	835	220	1,190	NA	79	1,020	NA	NA	858	NA	NA	94	91	566	NA	NA	623	102	NA	NA	NA	834	NA
Dissolved Oxygen	(mg/L)	7.6	NA	3.2	NA	NA	5.2	NA	NA	<0.2	NA	NA	NA	NA	<0.2	NA	NA	2.1	NA	NA	NA	NA	1	NA
Dissolved Lead	(mg/L)	NA	<0.027	NA	NA	<0.027	NA	NA	NA	NA	NA	NA	<0.0012	0.0034	NA	NA	NA	NA	<0.027	NA	NA	NA	NA	NA

Table 2-3
Summary of Site Ground-Water Quality Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Analytical Parameter	Units	CHT-7D			MW-8				MW-9				MW-9S		MW-10					MW-10D			
		4/11/94	6/2/94	10/1/96	9/29/92	4/7/94	6/3/94	9/28/96	10/7/92	10/7/92 D	4/7/94	10/14/96	10/7/92	9/28/96	10/6/92	4/8/94	4/8/94 D	5/31/94	9/28/96	10/6/92	4/8/94	5/31/94	10/10/96
Volatile Organic Compounds																							
Benzene	(ug/L)	<5	<10	<1	<10	<5	<10	<1	26	28	11	7	16	7	<33	<5	<5	<25	2 J	<50	<5	<10	<1
Toluene	(ug/L)	<5	<10	<1	<10	<5	<10	<2	<10	<10	<0.5	<5	2 J	<2	<33	<5	<5	<25	<2	<50	<5	<10	<1
Ethylbenzene	(ug/L)	<5	<10	<1	<10	<5	<10	<2	19	24	39	<5	5 J	<2	<33	<5	<5	<25	5	<50	<5	<10	<1
Total Xylenes	(ug/L)	<5	<10	<1	<10	<5	<10	<1	2 J	3 J	<5	<5	2 J	<1	<33	<5	<5	<25	<1	<50	<5	<10	<1
MTBE	(ug/L)	14	28 J	4 J	51	10	17 J	7	2,700 D	2,900 D	450	11	2,200 D	120	660	420	430	340 J	34	780	130	170 J	22
TCE	(ug/L)	14	10	6	14	9	10 J	12	<10	<10	<5	<5	<10	<1	29 J	14	12	18 J	17	18 J	11	14 J	18
PCE	(ug/L)	50	36	19	38	32	38 J	50	<10	<10	<5	<5	<10	<1	25 J	22	19	34 J	64	40 J	39	48 J	74
trans 1,2 DCE	(ug/L)	NA		<2	NA	NA		3 J	NA	NA	NA	<5	NA	<2	NA	NA	NA		4 J	NA	NA		<2
cis 1,2 DCE	(ug/L)	NA		47	NA	NA		100	NA	NA	NA	2 J	NA	<2	NA	NA	NA		120	NA	NA		150
1,2 DCE (total)	(ug/L)	140	91	NA	140	89	88 J	NA	<10	<10	<5	NA	2 J	NA	130	57	51	76 J	NA	180	100	110 J	NA
Vinyl Chloride	(ug/L)	<10	<10	NA	<10	<10	<10	NA	<10	<10	<10	NA	<10	NA	<33	17	16	<25	NA	<50	<10	<10	NA
Acetone	(ug/L)	NA		<6	<10	NA		<6	10 J	10 J	NA	11 J	<10 J	<6	45 J	NA	NA		<6	<50	NA		<6
Methylene Chloride	(ug/L)	<5		<2	<10	<5		<2	<10	<10	<5	<5	<10	<2	<21	<5	<5		<2	<50	<5		<2
Total Petroleum Hydrocarbons																							
Gasoline Range	(mg/L)	<0.4	NA	NA	NA	<0.4	NA	NA	NA	NA	5.1	NA	NA	NA	NA	<0.4	<0.4	NA	NA	NA	<0.4	NA	NA
Kerosene Range	(mg/L)	<0.4	NA	NA	NA	<0.4	NA	NA	NA	NA	<0.4	NA	NA	NA	NA	<0.4	<0.4	NA	NA	NA	<0.4	NA	NA
Diesel/#2 Range	(mg/L)	<0.4	NA	NA	NA	<0.4	NA	NA	NA	NA	<0.4	NA	NA	NA	NA	<0.4	<0.4	NA	NA	NA	<0.4	NA	NA
Total Petroleum Hydrocarbons	(mg/L)	NA	NA	NA	<0.5	NA	NA	NA	1.7	NA	NA	NA	21 D	NA	<0.5	NA	NA	NA	NA	<0.5	NA	NA	NA
Polynuclear Aromatic Hydrocarbons																							
Naphthalene	(ug/L)	<10	<10	NA	<10	<10	<10	NA	<10	NA	<10	NA	<10	NA	<10	<10	<10	<10	NA	<10	<10	<10	NA
Fluorene	(ug/L)	<2	<10	NA	<10	<2	<10	NA	5 J	NA	5	NA	9 J	NA	<10	<2	<2	<10	NA	<10	<2	<10	NA
Phenathrene	(ug/L)	<2	<10	NA	<10	<2	<10	NA	<10	NA	<2	NA	2 J	NA	<10	<2	<2	<10	NA	<10	<2	<10	NA
Anthracene	(ug/L)	<1	<10	NA	<10	<1	<10	NA	<10	NA	<1	NA	<10	NA	<10	<1	<1	<10	NA	<10	<1	<10	NA
Pyrene	(ug/L)	<2	<10	NA	<10	<2	<10	NA	<10	NA	<2	NA	<10	NA	<10	<2	<2	<10	NA	<10	<2	<10	NA
Chrysene	(ug/L)	<1	<10	NA	<10	<1	<10	NA	<10	NA	<1	NA	<10	NA	<10	<1	<1	<10	NA	<10	<1	<10	NA
Benzo(a) pyrene	(ug/L)	<0.2	<10	NA	<10	<0.2	<10	NA	<10	NA	<0.2	NA	<10	NA	<10	<0.2	<0.2	<10	NA	<10	<0.2	<10	NA
Benzo (g,h,i) perylene	(ug/L)	<0.5	<10	NA	<10	<0.5	<10	NA	<10	NA	<0.5	NA	<10	NA	<10	<0.5	<0.5	<10	NA	<10	<0.5	<10	NA
Benzo (b) fluoranthrene	(ug/L)	<0.2	<10	NA	<10	<0.2	<10	NA	<10	NA	<0.2	NA	<10	NA	<10	<0.2	<0.2	<10	NA	<10	<0.2	<10	NA
General Water Chemistry																							
Total Suspended Solids	(mg/L)	NA	<10	NA	NA	NA	478	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	45	NA	NA	NA	<10	NA
Carbon Dioxide	(mg/L)	523	NA	76	NA	572	NA	102	NA	NA	640	104	NA	173	NA	511	551	NA	89	NA	516	NA	74
Dissolved Oxygen	(mg/L)	3.4	NA	NA	NA	5	NA	NA	NA	NA	<0.2	NA	NA	NA	NA	1.9	2.1	NA	NA	NA	2.5	NA	NA

Notes:
1. NA = Not Analyzed.
2. R = Rejected.
3. J = Estimated value.
4. * = Elevated chlorinated organic detection limit as a result of aromatic hydrocarbon detections.

Table 2-4
Summary of Ground-Water Elevation Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Well Location	Top of Casing Elevation (feet)	Date	Depth to Product (feet)	Depth to Water (feet)	Apparent Product Thickness (feet)	Corrected Ground-Water Elevation (feet)
CHT-2	161.86	4/5/94	NE	13.94	0.00	147.92
		5/23/94	NE	15.05	0.00	146.81
		9/28/96	NE	11.88	0.00	149.98
		10/5/96	NE	11.65	0.00	150.21
		10/6/96	NE	11.62	0.00	150.24
		10/11/96	NE	12.10	0.00	149.76
		10/14/96	NE	12.17	0.00	149.69
CHT-3	161.86	4/5/94	NE	16.64	0.00	145.22
		5/23/94	NE	17.58	0.00	144.28
		9/28/96	16.86	16.98	0.12	144.97
		10/2/96	15.79	16.02	0.23	146.01
		10/3/96	16.40	16.64	0.24	145.40
		10/4/96	15.98	16.03	0.05	145.87
		10/5/96	15.92	15.95	0.03	145.93
		10/6/96	16.02	16.07	0.05	145.83
		10/11/96	17.02	17.05	0.03	144.83
		10/14/96	17.22	17.27	0.05	144.63
CHT-7D	158.29	5/23/94	NE	16.29	0.00	142.00
		9/30/96	NE	15.79	0.00	142.50
		10/6/96	NE	15.62	0.00	142.67
		10/11/96	NE	16.11	0.00	142.18
		10/14/96	NE	16.40	0.00	141.89
DW-1	167.16	4/5/94	NE	13.12	0.00	154.04
		5/10/94	NE	13.68	0.00	153.48
		5/23/94	NE	13.63	0.00	153.53
	166.98	10/5/96	NE	12.45	0.00	154.53
		10/6/96	NE	12.50	0.00	154.48
		10/11/96	NE	15.96	0.00	151.02
		10/14/96	NE	16.03	0.00	150.95
MW-8	167.54	9/10/92	NE	17.96	0.00	149.58
		9/17/92	NM	NM	NM	NM
		9/28/92	NE	17.03	0.00	150.51
		10/28/92	NE	12.00	0.00	155.54
		11/9/92	NE	12.57	0.00	154.97
		11/16/92	NE	12.20	0.00	155.34
		4/5/94	NE	13.13	0.00	154.41
		5/10/94	NE	13.70	0.00	153.84
		5/23/94	NE	13.64	0.00	153.90
	167.30	9/28/96	NE	14.95	0.00	152.35
		10/5/96	NE	12.53	0.00	154.77
		10/6/96	NE	12.60	0.00	154.70
		10/11/96	NE	15.57	0.00	151.73
		10/14/96	NE	15.61	0.00	151.69
MW-9	162.26	9/10/92	NE	NM	NM	NM
		9/17/92	NE	12.56	Sheen	149.70
		9/28/92	NE	12.49	0.00	149.77
		10/28/92	NE	11.33	0.00	150.93
		11/9/92	NE	NM	NM	NM
		11/16/92	NE	10.95	0.00	151.31
		5/10/94	NE	11.76	0.00	150.50
		5/23/94	NE	11.75	0.00	150.51
	162.26	10/5/96	NE	14.30	0.00	147.96
		10/6/96	NE	14.46	0.00	147.80
		10/14/96	NE	14.96	0.00	147.30

Table 2-4
Summary of Ground-Water Elevation Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Well Location	Top of Casing Elevation (feet)	Date	Depth to Product (feet)	Depth to Water (feet)	Apparent Product Thickness (feet)	Corrected Ground-Water Elevation (feet)
MW-9S	162.37	9/17/92	NE	13.22	Sheen	149.15
		9/28/92	13.00	13.11	0.11	149.34
		10/28/92	NE	10.92	Sheen	151.45
		11/9/92	NE	10.94	0.00	151.43
		11/16/92	NE	10.47	Sheen	151.90
		5/10/94	NE	11.54	0.00	150.83
		5/23/94	NE	11.56	0.00	150.81
	162.37	9/28/96	NE	14.40	0.00	147.97
		10/6/96	NE	11.29	0.00	151.08
		10/11/96	NE	11.95	0.00	150.42
		10/14/96	NE	12.02	0.00	150.35
MW-10	161.5	9/10/92	NE	20.66	0.00	140.84
		9/17/92	NE	20.70	0.00	140.80
		9/28/92	NE	20.52	0.00	140.98
		10/28/92	NE	17.66	0.00	143.84
		11/9/92	NE	17.42	0.00	144.08
		11/16/92	NE	16.72	0.00	144.78
		4/5/94	NE	17.68	0.00	143.82
		5/10/94	NE	17.58	0.00	143.92
		5/23/94	NE	17.65	0.00	143.85
		9/28/96	NE	16.92	0.00	144.58
		10/5/96	NE	16.97	0.00	144.53
		10/6/96	NE	17.05	0.00	144.45
		10/11/96	NE	17.69	0.00	143.81
		10/14/96	NE	17.97	0.00	143.53
MW-10D	161.38	9/10/92	NE	20.96	0.00	140.42
		9/17/92	NE	21.06	0.00	140.32
		9/28/92	NE	20.98	0.00	140.40
		10/28/92	NE	17.84	0.00	143.54
		11/9/92	NE	17.88	0.00	143.50
		11/16/92	NE	17.26	0.00	144.12
		4/5/94	NE	17.70	0.00	143.68
		5/10/94	NE	17.76	0.00	143.62
		5/23/94	NE	18.09	0.00	143.29
		9/28/96	NE	17.60	0.00	143.78
		10/5/96	NE	17.42	0.00	143.96
		10/6/96	NE	17.53	0.00	143.85
		10/11/96	NE	18.20	0.00	143.18
		10/14/96	NE	18.50	0.00	142.88
SW-1	166.36	12/20/93	NE	18.40	0.00	147.96
		4/5/94	NE	20.07	0.00	146.29
		5/10/94	NE	9.10	0.00	157.26
		5/23/94	NE	20.50	0.00	145.86
	166.35	9/27/96	NE	19.15	0.00	147.20
		9/27/96	NE	19.15	0.00	147.20
		10/3/96	NE	19.51	0.00	146.84
		10/4/96	NE	20.28	0.00	146.07
		10/5/96	NE	19.42	0.00	146.93
		10/6/96	NE	19.39	0.00	146.96
		10/11/96	NE	20.19	0.00	146.16

Table 2-4
Summary of Ground-Water Elevation Data
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Well Location	Top of Casing Elevation (feet)	Date	Depth to Product (feet)	Depth to Water (feet)	Apparent Product Thickness (feet)	Corrected Ground-Water Elevation (feet)
SW-2	166.52	12/20/93	NE	16.10	0.00	150.42
		4/5/94	NE	17.53	0.00	148.99
		5/10/94	NE	18.45	0.00	148.07
		5/23/94	NE	17.43	0.00	149.09
	166.67	9/27/96	NE	17.00	0.00	149.67
		9/27/96	NE	17.00	0.00	149.67
		10/3/96	NE	17.65	0.00	149.02
		10/3/96	NE	17.72	0.00	148.95
		10/3/96	NE	17.72	0.00	148.95
		10/4/96	NE	17.40	0.00	149.27
		10/5/96	NE	17.21	0.00	149.46
		10/6/96	NE	17.25	0.00	149.42
		10/11/96	NE	18.45	0.00	148.22
		10/14/96	NE	18.65	0.00	148.02
SW-3	166.68	12/20/93	NE	15.79	0.00	150.89
		4/5/94	NE	17.16	0.00	149.52
		5/10/94	NE	18.96	0.00	147.72
		5/23/94	NE	17.62	0.00	149.06
	166.65	9/27/96	16.30	16.60	0.30	150.27
		10/1/96	16.70	16.99	0.29	149.87
		10/3/96	17.02	17.29	0.27	149.56
		10/3/96	17.02	17.29	0.27	149.56
		10/3/96	17.02	17.28	0.26	149.56
		10/4/96	17.36	17.59	0.23	149.23
		10/5/96	27.94	27.96	0.02	138.70
		10/6/96	23.61	23.66	0.05	143.03
		10/11/96	16.98	17.01	0.03	149.66
		10/12/96	17.14	17.18	0.04	149.50
		10/14/96	17.25	17.32	0.07	149.38
SW-7	167.02	12/20/93	9.41	9.40	0.01	157.63
		4/5/94	NE	9.72	0.00	157.30
		5/10/94	NE	10.08	0.00	156.94
		5/23/94	NE	10.77	0.00	156.25
	167.00	9/19/96	9.21	9.55	0.34	157.75
		10/3/96	9.45	9.67	0.22	157.52
		10/5/96	9.50	9.51	0.01	157.50
		10/6/96	9.55	9.60	0.05	157.44
		10/11/96	9.58	9.60	0.02	157.42
		10/12/96	9.61	9.64	0.03	157.39
		10/14/96	9.59	9.61	0.02	157.41
SW-8	167.47	9/23/96	NE	19.90	0.00	147.57
		9/24/96	NE	20.00	0.00	147.47
		9/25/96	NE	20.22	0.00	147.25
		9/26/96	NE	20.30	0.00	147.17
		10/3/96	NE	20.46	0.00	147.01
		10/5/96	NE	20.26	0.00	147.21
		10/6/96	NE	20.34	0.00	147.13
		10/11/96	NE	20.96	0.00	146.51
		10/14/96	NE	21.16	0.00	146.31

Notes:
1. NE = Not Encountered.
2. NM = Not Measured.
3. A specific gravity of 0.88 was used to calculate corrected ground-water elevation in monitoring well SW-7. In any other monitoring wells containing free product a value of 0.74 was used.

Table 2-5
Summary of Phase-Separated Hydrocarbon Analyses
Esso Tutu Service Station
St. Thomas, U.S.V.I.
(all units reported as ppm)

Analytical Parameter	SW-3		SW-7		CHT-3	
	FES	EPA	FES	EPA	FES	EPA
Gasoline Additives						
MTBE	360	NA	10	NA	84	NA
DIPE	<50	NA	<2	NA	<50	NA
ETBE	<50	NA	<2	NA	<50	NA
TAME	<50	NA	<2	NA	<50	NA
Volatile Organic Compounds (EPA Method 8260)						
Benzene	990	2,500	8	<150	470	2.4 J
Toluene	200	<1,600	<2	<150	360	0.330 J
Ethylbenzene	8,600	8,700	62	35 J	11,000 *	3.5 J
m, p Xylene	17,000*		10		11,000*	
o Xylene	6,400		31		4,000	
Total Xylenes	23,400	36,000	41	50 J	15,000	6.8 J
Isopropylbenzene	4,400		55		6,500	
n-Propylbenzene	14,000*		210		15,000*	
Propylbenzene		15,000 J		140 J		3.3 J
1,3,5 Trimethylbenzene	14,000*		84		16,000*	
Trimethylbenzene		110,000 J		200 J		22 J
Ethyl-Methyl-Benzene		69,000 J		150 J		16 J
Diethyl Benzene				140 J		
Ethyl Dimethyl Benzene		25,000 J		560 J		2.8 J
Tetramethyl Benzene				260 J		
Ethenyl Dimethyl Benzene				210 J		
Dihydromethyl-1W-Indene				410 J		
Dihydrodimethyl-1W-Indene				190 J		
Ethyltrimethyl Benzene				160 J		
Hydrocarbons		28,000 J				
Dimethyl Heptane		9,400 J				
Methyl Heptane		13,000 J				
Trimethyl Heptane		15,000 J				
Methylpropylbenzene		14,000 J				1.5 J
Methoxy Methyl Propane						3 J
Methyl (Methyl Ethyl) Benzene						2.5 J
Indane						2.2 J
Unknown Compound #1						1.2 J
4-Chlorotoluene	860		13		<50	
1,2,4 Trimethylbenzene	19,000		120		20,000*	
sec-Butylbenzene	<50		35		3,100	
1,2 Dichlorobenzene	<50		15		<50	
1,4 Dichlorobenzene	<50		2		<50	
Trichloroethene	<50	<1,600	<2	<150	<50	
Tetrachloroethene	<50	<1,600	<2	<150	<50	
1,1, Dichloroethene	<50	<1,600	<2	<150	<50	
cis 1,2 Dichloroethene	<50		<2		<50	
trans 1,2 Dichloroethene	<50	<1,600	<2	<150	<50	
Naphthalene	5,300		300		4,100	0.890 J
Alcohols						
Methanol	<25	NA	<25	NA	<25	NA
2-Methyl-2-propanol	<25	NA	<25	NA	<25	NA
Ethanol	55	NA	<25	NA	31	NA
2-Butanol	<25	NA	<25	NA	<25	NA
1-Propanol	<25	NA	<25	NA	<25	NA
2-Methyl-1-propoanol	<25	NA	<25	NA	<25	NA
Neopentyl alcohol	<25	NA	<25	NA	<25	NA
1-Butanol	<25	NA	<25	NA	<25	NA
Lead Alkyls						
Tetramethyl Lead	<5	NA	<5	NA	<5	NA
Trimethylethyl Lead	<5	NA	<5	NA	<5	NA
Dimethyl-diethyl Lead	<5	NA	<5	NA	<5	NA
Triethyl-methyl Lead	<5	NA	<5	NA	<5	NA
Tetraethyl Lead	<5	NA	<5	NA	<5	NA

Notes:
1. MTBE = Methyl t-butyl ether.
2. DIPE = Diisopropyl ethe:
3. ETBE = Ethyl t-butyl ether.
4. TAME = t-Amyl methyl ether.
5. * = "The value reported exceeded the highest calibration standard."

Table 4-1a
Air Emissions Calculations (Average System Discharge)
SVE/Bioventing System
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Compound	Average Soil Vapor Concentration		Molecular Weight	Average Contaminant Mass Per Well				Contaminant Mass All Wells @ 125 cfm		Contaminant Mass All Wells @ 175 cfm	
	ppbv	ppmv	gm/mole	mg/m^3	kg/m^3	kg/ft^3	lbs/ft^3	lbs/cfm	$lbs/ft^3/hour$	lbs/cfm	$lbs/ft^3/hour$
Pentane	123200	123.200	72.2	363.805	3.64E-04	1.03E-05	2.27E-05	0.0028	0.170	0.0040	0.239
Hexane	9300	9.300	86.2	32.788	3.28E-05	9.29E-07	2.05E-06	0.0003	0.015	0.0004	0.021
Heptane	74	0.074	100.2	0.303	3.03E-07	8.59E-09	1.89E-08	2.37E-06	1.42E-04	3.31E-06	1.99E-04
Isooctane	4530	4.530	114.2	21.159	2.12E-05	5.99E-07	1.32E-06	0.0002	0.010	0.0002	0.014
Octane	434	0.434	114.2	2.027	2.03E-06	5.74E-08	1.27E-07	1.58E-05	0.001	2.21E-05	0.001
Benzene	1910	1.910	78.1	6.101	6.10E-06	1.73E-07	3.81E-07	4.76E-05	0.003	6.67E-05	0.004
MTBE	7	0.007	88.2	0.025	2.52E-08	7.15E-10	1.58E-09	1.97E-07	1.18E-05	2.76E-07	1.65E-05
Toluene	316	0.316	92.1	1.190	1.19E-06	3.37E-08	7.43E-08	9.29E-06	0.001	1.30E-05	0.001
Ethylbenzene	4026	4.026	106.2	17.487	1.75E-05	4.95E-07	1.09E-06	0.0001	0.008	0.0002	0.011
m- & p- Xylenes	372	0.372	106.2	1.616	1.62E-06	4.58E-08	1.01E-07	1.26E-05	0.001	1.77E-05	0.001
o-Xylenes	104	0.104	106.2	0.452	4.52E-07	1.28E-08	2.82E-08	3.53E-06	2.12E-04	4.94E-06	2.96E-04
4-Ethyltoluene	256	0.256	120.2	1.259	1.26E-06	3.56E-08	7.86E-08	9.82E-06	0.001	1.38E-05	0.001
Cumene	1453	1.453	120.2	7.143	7.14E-06	2.02E-07	4.46E-07	0.0001	0.003	7.80E-05	0.005
1,2,4 Trimethylbenzene	406	0.406	120.2	1.996	2.00E-06	5.65E-08	1.25E-07	1.56E-05	9.35E-04	2.18E-05	1.31E-03
1,3,5 Trimethylbenzene	142	0.142	120.2	0.698	6.98E-07	1.98E-08	4.36E-08	5.45E-06	3.27E-04	7.63E-06	4.58E-04
Carbon Disulfide	19	0.019	76.1	0.059	5.91E-08	1.67E-09	3.69E-09	4.62E-07	2.77E-05	6.46E-07	3.88E-05
Freon 113	19	0.019	187.4	0.146	1.46E-07	4.12E-09	9.09E-09	1.14E-06	6.82E-05	1.59E-06	9.55E-05
Trichloroethene	18	0.018	131.4	0.097	9.67E-08	2.74E-09	6.04E-09	7.55E-07	4.53E-05	1.06E-06	6.34E-05
Tetrachloroethane	101	0.101	165.8	0.685	6.85E-07	1.94E-08	4.28E-08	5.35E-06	3.21E-04	7.48E-06	4.49E-04
TICs/C_3-C_4	12107	12.107	86.2	42.684	4.27E-05	1.21E-06	2.67E-06	0.0003	0.020	0.0005	0.028
TICs/C_5-C_{10}	9990	9.990	184.4	75.344	7.53E-05	2.13E-06	4.70E-06	5.88E-04	0.035	0.0008	0.049
	A	B = A/1000	C	D = BxC/24.45	E = D/1000000	F = E/35.31	G = Fx2.20	H = Gx125	I = Hx60	H = Gx125	I = Hx60

Total vapor contaminant mass removed by treatment system in pounds/hour = 0.270 (@ 125 cfm); 0.378 (@ 175 cfm)

Total estimated air emission in pounds/hour (assumes minimum cat-ox destruction efficiency of 95%) = 0.014 (@ 125 cfm); 0.019 (@ 175 cfm)

ppbv = parts per billion by volume, ppmv = parts per million by volume, mg = milligrams, gm = grams,
kg = kilograms, lbs = pounds, m^3 = cubic meters, ft^3 = cubic feet, cfm = cubic feet per minute
TICs = tentatively identified compounds. For estimation purposes, the TIC with the highest molecular weight in each group (2,2-dimethylbutane, 2,3,4,-trimethyldecane) was used in the calculations.
Average soil vapor concentrations based on quantitative vapor samples collected at the site in September/October 1996.
Total estimated air flow from all wells is estimated at 125 cfm. Catalytic oxidizer will provide at least 95% treatment efficiency.

Table 4-1b
Air Emissions Calculations (Maximum System Discharge)
SVE/Bioventing System
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Compound	Maximum Soil Vapor Concentration		Molecular Weight	Average Contaminant Mass Per Well				Contaminant Mass All Wells @ 125 cfm		Contaminant Mass All Wells @ 175 cfm	
	ppbv	ppmv	gm/mole	mg/m^3	kg/m^3	kg/ft^3	lbs/ft^3	lbs/cfm	lbs/ft^3/hour	lbs/cfm	lbs/ft^3/hour
Pentane	260000	260.000	72.2	767.771	7.68E-04	2.17E-05	4.79E-05	0.0060	0.360	0.0084	0.503
Hexane	19000	19.000	86.2	66.986	6.70E-05	1.90E-06	4.18E-06	0.0005	0.031	0.0007	0.044
Heptane	200	0.200	100.2	0.820	8.20E-07	2.32E-08	5.12E-08	6.40E-06	3.84E-04	8.96E-06	5.37E-04
Isooctane	9200	9.200	114.2	42.971	4.30E-05	1.22E-06	2.68E-06	0.0003	0.020	0.0005	0.028
Octane	1300	1.300	114.2	6.072	6.07E-06	1.72E-07	3.79E-07	4.74E-05	0.003	0.0001	0.004
Benzene	5500	5.500	78.1	17.569	1.76E-05	4.98E-07	1.10E-06	0.0001	0.008	0.0002	0.012
MTBE	20	0.020	88.2	0.072	7.21E-08	2.04E-09	4.50E-09	5.63E-07	3.38E-05	7.88E-07	4.73E-05
Toluene	920	0.920	92.1	3.466	3.47E-06	9.81E-08	2.16E-07	2.70E-05	0.002	3.79E-05	0.002
Ethylbenzene	12000	12.000	106.2	52.123	5.21E-05	1.48E-06	3.25E-06	0.0004	0.024	0.0006	0.034
m- & p- Xylenes	1100	1.100	106.2	4.778	4.78E-06	1.35E-07	2.98E-07	3.73E-05	0.002	0.0001	0.003
o-Xylenes	300	0.300	106.2	1.303	1.30E-06	3.69E-08	8.14E-08	1.02E-05	6.10E-04	1.42E-05	8.54E-04
4-Ethyltoluene	760	0.760	120.2	3.736	3.74E-06	1.06E-07	2.33E-07	2.92E-05	0.002	4.08E-05	0.002
Cumene	4300	4.300	120.2	21.139	2.11E-05	5.99E-07	1.32E-06	0.0002	0.010	0.0002	0.014
1,2,4 Trimethylbenzene	1200	1.200	120.2	5.899	5.90E-06	1.67E-07	3.68E-07	4.60E-05	0.003	0.0001	0.004
1,3,5 Trimethylbenzene	420	0.420	120.2	2.065	2.06E-06	5.85E-08	1.29E-07	1.61E-05	9.67E-04	2.26E-05	0.001
Carbon Disulfide	50	0.050	76.1	0.156	1.56E-07	4.41E-09	9.72E-09	1.21E-06	7.29E-05	1.70E-06	1.02E-04
Freon 113	50	0.050	187.4	0.383	3.83E-07	1.09E-08	2.39E-08	2.99E-06	1.79E-04	4.19E-06	2.51E-04
Trichloroethene	29	0.029	131.4	0.156	1.56E-07	4.41E-09	9.73E-09	1.22E-06	7.30E-05	1.70E-06	1.02E-04
Tetrachloroethane	230	0.230	165.8	1.560	1.56E-06	4.42E-08	9.74E-08	1.22E-05	7.30E-04	1.70E-05	0.001
TICs/C_3-C_4	31500	31.500	86.2	111.055	1.11E-04	3.15E-06	6.93E-06	0.0009	0.052	0.0012	0.073
TICs/C_5-C_{10}	26000	26.000	184.4	196.090	1.96E-04	5.55E-06	1.22E-05	0.0015	0.092	2.14E-03	0.129
	A	B = A/1000	C	D = BxC/24.45	E = D/1000000	F = E/35.31	G = Fx2.20	H = Gx125	I = Hx60	H = Gx125	I = Hx60
Total vapor contaminant mass removed by treatment system in pounds/hour =									0.612		0.856
Total estimated air emission in pounds/hour (assumes minimum cat-ox destruction efficiency of 95%) =									**0.031**		**0.043**

ppbv = parts per billion by volume, ppmv = parts per million by volume, mg = milligrams, gm = grams,
kg = kilograms, lbs = pounds, m^3 = cubic meters, ft^3 = cubic feet, cfm = cubic feet per minute
TICs = tentatively identified compounds. For estimation purposes, the TIC with the highest molecular weight in each group (2,2-dimethylbutane, 2,3,4,-trimethyldecane) was used in the calculations.
Maximum soil vapor concentrations based on quantitative vapor samples collected at the site in September/October 1996.
Total estimated air flow from all wells is estimated at 125 cfm. Catalytic oxidizer will provide at least 95% treatment efficiency.

Table 4-2
Ground-Water Contaminant Calculations
Ground-Water Extraction System (Air Stripper Design)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Ground-Water Extraction Well (representative wells)	Water Source/ Expected Yield	% System Total Flow
G1 (SW-7)	perched water table/ 0.5 gpm	8.3%
G2 (SW-7)	perched water table/ 0.5 gpm	8.3%
G3 (SW-7)	perched water table/ 0.5 gpm	8.3%
G4 (SW-7)	perched water table/ 0.5 gpm	8.3%
G5 (SW-3)	shallow Tutu Aquifer/ 1.0 gpm	16.7%
G6 (MW-9, MW-9S, CHT-2)	shallow Tutu Aquifer/ 1.0 gpm	16.7%
G7 (SW-8)	shallow Tutu Aquifer/ 1.0 gpm	16.7%
G8 (MW-10, MW-10D, SW-1, CHT-3)	shallow Tutu Aquifer/ 1.0 gpm	16.7%

gpm = gallons per minute
All 1996 data from representative wells averaged to calculate weighted concentrations except G8; MW-10 & MW-10D averaged for CVOCs, SW-1 & CHT-2 averaged for VOCs to provide "worst-case" scenarios.

Compound	Weighted Flow Concentration mg/L	Design Concentration mg/L
Benzene	2222	2,250
Toluene	134	150
Ethylbenzene	684	700
Xylenes	1856	1,900
Total BTX	4211	4,300
MTBE	19939	20,000
Tetrachloroethene	12	5
Trichloroethene	3	15
1,2 Dichloroethene (total)	24	25
Vinyl Chloride	3	5
Acetone	2	5
Methylene Chloride	14	15

µg/L = micrograms per liter

Table 4-3
Air Emissions Calculations
Ground-Water Extraction System (Air Stripper Off-Gas)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Compound	Weighted Flow Concentration			Contaminant Mass @ 10 gpm			Total Contaminant Mass in lbs/hr		
	µg/L	mg/L	gm/L	gm/gal	gm/min	gm/hr	6 gpm	10 gpm	12gpm
Benzene	2222	2.222	0.0022	0.0084	0.0841	5.0456	0.0070	0.0116	0.0139
Toluene	134	0.134	0.0001	0.0005	0.0051	0.3036	0.0004	0.0007	0.0008
Ethylbenzene	684	0.684	0.0007	0.0026	0.0259	1.5541	0.0021	0.0036	0.0043
Xylenes	1856	1.856	0.0019	0.0070	0.0702	4.2144	0.0058	0.0097	0.0116
MTBE	19939	19.939	0.0199	0.0755	0.7547	45.2813	0.0624	0.1040	0.1248
Tetrachloroethene	12	0.012	1.20E-05	4.54E-05	0.0005	0.0273	3.75E-05	0.0001	0.0001
Trichloroethene	3	0.003	3.00E-06	1.14E-05	0.0001	0.0068	9.39E-06	1.56E-05	1.88E-05
1,2 Dichloroethene (total)	23	0.023	2.30E-05	0.0001	0.0009	0.0522	0.0001	0.0001	0.0001
Vinyl Chloride	3	0.003	3.00E-06	1.14E-05	0.0001	0.0068	9.39E-06	1.56E-05	1.88E-05
Acetone	2	0.002	2.00E-06	7.57E-06	0.0001	0.0045	6.26E-06	1.04E-05	1.25E-05
Methylene Chloride	14	0.014	1.40E-05	0.0001	0.0005	0.0318	4.38E-05	0.0001	0.0001
	A	B = A/1000	C = B/1000	D = Cx3.785	E = Dx10	F = Ex60	G = H/0.6	H = F/435.5	I = H*1.2

Total estimated air emission in pounds/hour (assumes 100% air stripper efficiency) =	0.0779	0.1298	0.1558

L = liters, µg = microgram, mg = milligrams, gm = grams, gal = gallons, gpm = gallons per minute, min = minutes, lbs = pounds, hr = hour
Weighted contaminant concentrations based on quantitative ground-water samples collected at the site in September/October 1996.
Table 4-2 provides assumptions used to calculate weighted flow concentrations.
Estimate assumes air stripper will operation with a 100% treatment efficiency.

Table 6-1
ITP Monitoring Summary - Remedial Work Element I
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Time From Initial System Operation	Project Phase	Treatment System Component	Sample Location	Sampling/Monitoring Parameter	Sampling Frequency
0-2 Weeks	Remedial Work Element I	Cat-Ox Air Pollution Control	Vapor Influent/Effluent	VOCs via TO-14	Twice per week
			Vapor Influent/Effluent	VOCs via field PID	Four times per week
			Vapor Effluent	CO/O_2 via field meter	Four times per week
			Vapor Effluent	discharge velocity via field meter	Four times per week
			Vapor Effluent	temperature, flow rate via cat-ox	Four times per week
		SVE	Individual SVE Wells	VOCs via PID	Four times per week
			Individual SVE Wells	CO_2/O_2 via field meter	Four times per week
			Individual SVE Wells	Vacuum, flow rate at well via field gauge	Four times per week
			Individual VMPs	Induced vacuum at well via field gauge	Four times per week
			Ambient Site Conditions	Barometric pressure, temperature via field meter	Four times per week
2- 8 Weeks	Remedial Work Element I	Cat-Ox Air Pollution Control	Vapor Influent/Effluent	VOCs via TO-14	Twice per month
			Vapor Influent/Effluent	VOCs via field PID	Twice per week
			Vapor Effluent	CO/O_2 via field meter	Twice per week
			Vapor Effluent	discharge velocity via field meter	Twice per week
			Vapor Effluent	temperature, flow rate via cat-ox	Twice per week
		SVE	Individual SVE Wells	VOCs via TO-14	Monthly
			Individual SVE Wells	VOCs via PID	Twice per week
			Individual SVE Wells	CO_2/O_2 via field meter	Twice per week
			Individual SVE Wells	Vacuum, flow rate at well via field gauge	Twice per week
			Individual VMPs	Induced vacuum at well via field gauge	Twice per week
			Ambient Site Conditions	Barometric pressure, temperature via field meter	Twice per week
2-4 months	Remedial Work Element I	Cat-Ox Air Pollution Control	Vapor Influent/Effluent	VOCs via TO-14	Monthly
			Vapor Influent/Effluent	VOCs via field PID	Weekly
			Vapor Effluent	CO/O_2 via field meter	Weekly
			Vapor Effluent	discharge velocity via field meter	Weekly
			Vapor Effluent	temperature, flow rate via cat-ox	Weekly
		SVE	Individual SVE Wells	VOCs via TO-14	Periodically
			Individual SVE Wells	VOCs via PID	Monthly
			Individual SVE Wells	CO_2/O_2 via field meter	Monthly
			Individual SVE Wells	Vacuum, flow rate at well via field gauge	Monthly
			Individual VMPs	Induced vacuum at well via field gauge	Monthly
			Ambient Site Conditions	Barometric pressure, temperature via field meter	Monthly

VMPs = vapor monitoring points, VOCs = volatile organic compounds, PID = photoionization detector

Table 6-2
ITP Monitoring Summary - Remedial Work Element II
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Time From Initial System Operation	Project Phase	Treatment System Component	Sample Location	Sampling/Monitoring Parameter	Sampling Frequency
0-2 weeks	Remedial Work Element II	Ground-Water	all on-site wells plus CHT-2, CHT-3, CHT-4, CHT-7D, MW-9S, MW-9, MW-10, MW-10D, G6, and G8	Liquid-level measurements	Daily
			MW-8, DW-1	Water level measurements	Continuous
			G-W Recovery Wells	Total gallons extracted	Daily
		Air Stripper (AS)	G-W Influent	VOCs via 8240 & 8270	Monthly (first 15 days)
		AS/TPDES	G-W Effluent	BTEX via 8240	Weekly
		AS/TPDES	G-W Influent/Effluent	TPH via 8015A	Weekly
		TPDES	G-W Influent/Effluent	lead via 7421	Weekly
		TPDES	G-W Effluent	pH via field meter, discharge flow rate	Weekly
		TPDES	G-W Effluent	TOC via 9060A, TSS via 160.2	Weekly
2-8 weeks	Remedial Work Element II	Ground-Water	all on-site wells plus CHT-2, CHT-3, CHT-4, CHT-7D, MW-9S, MW-9, MW-10, MW-10D, G6, and G8	Liquid-level measurements	Weekly
			MW-8, DW-1	Water level measurements	Continuous
			G-W Recovery Wells	Total gallons extracted	Weekly
			G-W Recovery Wells	Dissolved oxygen via field meter	Monthly
			G-W Recovery Wells	VOCs via 8240, TPH via 8015A	Monthly
			G-W Recovery Wells	Hardness via 130.2, iron via 6010B	One Event
			SW-1, SW-3, SW-8, SW-9, and SW-10	VOCs via 8240, TPH via 8015A	Monthly
		Air Stripper (AS)	G-W Influent	VOCs via 8240 & 8270	Monthly
		AS/TPDES	G-W Effluent	BTEX via 8240	Weekly
		AS/TPDES	G-W Influent/Effluent	TPH via 8015A	Weekly
		TPDES	G-W Influent/Effluent	lead via 7421	Weekly
		TPDES	G-W Effluent	pH via field meter, discharge flow rate	Weekly
		TPDES	G-W Effluent	TOC via 9060A, TSS via 160.2	Weekly
2-4 months	Remedial Work Element II	Ground-Water	all on-site wells plus CHT-2, CHT-3, CHT-4, CHT-7D, MW-9S, MW-9, MW-10, MW-10D, G6, and G8	Liquid-level measurements	Weekly
			MW-8, DW-1	Water level measurements	Continuous
			G-W Recovery Wells	Total gallons extracted	Monthly
			G-W Recovery Wells	Dissolved oxygen via field meter	Monthly
			G-W Recovery Wells	VOCs via 8240, TPH via 8015A	Monthly
			G-W Recovery Wells	Hardness via 130.2, iron via 6010B	Periodically
			SW-1, SW-3, SW-8, SW-9, and SW-10	VOCs via 8240, TPH via 8015A	Monthly
		Air Stripper (AS)	G-W Influent	VOCs via 8240 & 8270	Monthly
		AS/TPDES	G-W Effluent	BTEX via 8240	Monthly
		AS/TPDES	G-W Influent/Effluent	TPH via 8015A	Monthly
		TPDES	G-W Effluent	lead via 7421	Monthly
		TPDES	G-W Effluent	pH via field meter, discharge flow rate	Weekly
		TPDES	G-W Effluent	TOC via 9060A, TSS via 160.2	Weekly

VOCs = volatile organic compounds, TPH = total petroleum hydrocarbons, TOC = total organic carbon, TSS total suspended solids
Air stripper discharge is regulated by a DPNR Air Pollution Control Permit.

Table 6-3
Compliance Monitoring Summary
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Time From Initial System Operation	Project Phase	Permit Type	Sample Location	Sampling/Monitoring Parameter	Sampling Frequency
4-6 months	Remedial Work Element I	Cat-Ox Air Pollution Control	Vapor Influent/Effluent	VOCs via TO-14	Monthly
			Vapor Influent/Effluent	VOCs via field PID	Weekly
			Vapor Effluent	CO/O_2 via field meter	Weekly
			Vapor Effluent	discharge velocity via field meter	Weekly
			Vapor Effluent	temperature, flow rate via cat-ox	Weekly
	Remedial Work Element II	Air Stripper (AS)	G-W Influent	VOCs via 8240 & 8270	Monthly
		AS/TPDES	G-W Effluent	BTEX via 8240	Monthly
		AS/TPDES	G-W Influent/Effluent	TPH via 8015A	Monthly
		TPDES	G-W Effluent	lead via 7421	Monthly
		TPDES	G-W Effluent	pH via field meter, discharge flow rate	Weekly
		TPDES	G-W Effluent	TOC via 9060A, TSS via 160.2	Weekly
6-12 months	Remedial Work Element I	Cat-Ox Air Pollution Control	Vapor Influent/Effluent	VOCs via TO-14	Monthly
			Vapor Influent/Effluent	VOCs via field PID	Monthly
			Vapor Effluent	CO/O_2 via field meter	Monthly
			Vapor Effluent	discharge velocity via field meter	Monthly
			Vapor Effluent	temperature, flow rate via cat-ox	Monthly
	Remedial Work Element II	Air Stripper (AS)	G-W Influent	VOCs via 8240 & 8270	Monthly*
		TPDES	G-W Effluent	BTEX via 8240	Monthly
		AS	G-W Influent	TPH via 8015A	Quarterly*
		TPDES	G-W Effluent	TPH via 8015A	Quarterly
		TPDES	G-W Effluent	lead via 7421	Monthly
		TPDES	G-W Effluent	pH via field meter, discharge flow rate	Weekly
		TPDES	G-W Effluent	TOC via 9060A, TSS via 160.2	Weekly
after 1 year	Remedial Work Element I	Cat-Ox Air Pollution Control	Vapor Influent/Effluent	VOCs via TO-14	Monthly*
			Vapor Influent/Effluent	VOCs via field PID	Monthly
			Vapor Effluent	CO/O_2 via field meter	Monthly
			Vapor Effluent	discharge velocity via field meter	Monthly
			Vapor Effluent	temperature, flow rate via cat-ox	Monthly
	Remedial Work Element II	Air Stripper (AS)	G-W Influent	VOCs via 8240 & 8270	Monthly*
		TPDES	G-W Effluent	BTEX via 8240	Monthly
		AS	G-W Influent	TPH via 8015A	Quarterly*
		TPDES	G-W Effluent	TPH via 8015A	Quarterly
		TPDES	G-W Effluent	lead via 7421	Monthly*
		TPDES	G-W Effluent	pH via field meter, discharge flow rate	Weekly*
		TPDES	G-W Effluent	TOC via 9060A, TSS via 160.2	Weekly*

* Based on previous analytical results, DPNR may be petitioned to reduce the monitoring frequency.
VOCs = volatile organic compounds, TPH = total petroleum hydrocarbons, TOC = total organic carbon, TSS total suspended solids
Air stripper discharge is regulated by DPNR Air Pollution Control Permit.

Table 6-4
Performance Monitoring Summary
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Time From Initial System Operation	Project Phase	Treatment System	Sample Location	Sampling/Monitoring Parameter	Sampling Frequency
4-6 months	Remedial Work Element I	SVE	Individual SVE Wells	VOCs via TO-14	Periodically
			Individual SVE Wells	VOCs via PID	Monthly
			Individual SVE Wells	CO_2/O_2 via field meter	Monthly
			Individual SVE Wells	Vacuum, flow rate at well via field gauge	Monthly
			Individual VMPs	Induced vacuum at well via field gauge	Monthly
			Ambient Site Conditions	Barometric pressure, temperature via field meter	Monthly
	Remedial Work Element II	Ground-Water	all on-site wells plus CHT-2, CHT-3, CHT-4, CHT-7D, MW-9S, MW-9, MW-10, MW-10D, G6, and G8	Liquid-level measurements	Weekly
			MW-8, DW-1	Water level measurements	Continuous
			G-W Recovery Wells	Total gallons extracted	Monthly
			G-W Recovery Wells	Dissolved oxygen via field meter	Monthly
			G-W Recovery Wells	VOCs via 8240, TPH via 8015A	Monthly
			G-W Recovery Wells	Hardness via 130.2, iron via 6010B	Periodically
			SW-1, SW-3, SW-8, SW-9, and SW-10	VOCs via 8240, TPH via 8015A	Monthly
6-12 months	Remedial Work Element I	SVE/ Bioventing	Individual SVE/BE Wells	VOCs via TO-14	Periodically
			Individual SVE/BE Wells	VOCs via PID	Quarterly
			Individual SVE Wells	CO_2/O_2 via field meter	Quarterly
			Individual BE Wells/VMPs	CO_2/O_2/methane via field meter	Quarterly
			Individual SVE/BE Wells	Vacuum, flow rate at well via field gauge	Quarterly
			Individual VMPs	Induced vacuum at well via field gauge	Quarterly
			Individual BI Wells	Vacuum, flow rate at well via field gauge	Quarterly
			Ambient Site Conditions	Barometric pressure, temperature via field meter	Monthly
	Remedial Work Element II	Ground-Water	all on-site wells plus CHT-2, CHT-3, CHT-4, CHT-7D, MW-9S, MW-9, MW-10, MW-10D, G6, and G8	Liquid-level measurements	Weekly
			MW-8, DW-1	Water level measurements	Continuous
			G-W Recovery Wells and G-W System	Total gallons extracted	Monthly
			G-W Recovery Wells	Dissolved oxygen via field meter	Periodically
			G-W Recovery Wells	VOCs via 8240, TPH via 8015A	Quarterly
			G-W Recovery Wells	Hardness via 130.2, iron via 6010B	Periodically
			SW-1, SW-3, SW-8, SW-9, and SW-10	VOCs via 8240, TPH via 8015A	Quarterly
after 1 year	Remedial Work Element I	SVE/ Bioventing	Individual SVE/BE Wells	VOCs via TO-14	Periodically
			Individual SVE/BE Wells	VOCs via PID	Quarterly
			Individual SVE Wells	CO_2/O_2 via field meter	Quarterly
			Individual BE Wells/VMPs	CO_2/O_2/methane via field meter	Quarterly
			Individual SVE/BE Wells	Vacuum, flow rate at well via field gauge	Quarterly
			Individual VMPs	Induced vacuum at well via field gauge	Quarterly
			Individual BI Wells	Vacuum, flow rate at well via field gauge	Quarterly
			Ambient Site Conditions	Barometric pressure, temperature via field meter	Monthly
	Remedial Work Element II	Ground-Water	all on-site wells plus CHT-2, CHT-3, CHT-4, CHT-7D, MW-9S, MW-9, MW-10, MW-10D, G6, and G8	Liquid-level measurements	Quarterly
			G-W Recovery Wells and G-W System	Total gallons extracted	Monthly
			G-W Recovery Wells	Dissolved oxygen via field meter	Periodically
			G-W Recovery Wells	VOCs via 8240, TPH via 8015A	Quarterly
			G-W Recovery Wells	Hardness via 130.2, iron via 6010B	Periodically
			SW-1, SW-3, SW-8, SW-9, and SW-10	VOCs via 8240, TPH via 8015A	Quarterly

VMP = vapor monitoring point, BE = bioventing extraction, BI = bioventing injection, PID = photoionization detector
VOCs = volatile organic compounds, TPH = total petroleum hydrocarbons

Table 6-5
Post-Remediation Monitoring Summary
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Time From Initial System Operation	Project Phase	Treatment System	Sample Medium	Sample Location	Sampling Analysis	Sampling Frequency
after achievement of Performance Standards (see Sections 5.0 and 5.1)	Remedial Work Element I	SVE/ Bioventing	Soil	2 borings near north oil/water separator 3 borings south of the oil/water separator 2 borings south of the dispenser islands	VOCs via 8240 TPH via 8015A PAHs via 8310	Once
after achievement of Performance Standards (see Sections 5.2 and 5.3)	Remedial Work Element II	Ground-Water Treatment	Ground Water	all on-site wells plus CHT-2, CHT-3, CHT-4, CHT-7D, MW-9S, MW-9, MW-10, MW-10D, G6, and G8	VOCs via 8240 TPH via 8015A	Annually for Three Years

VOCs = volatile organic compounds, TPH = total petroleum hydrocarbons, PAHs = polycyclic aromatic hydrocarbons

Table 8-1
Construction Cost Estimate
Tutu Source Control Program
Esso Tutu Service Station
St. Thomas, U.S.V.I.

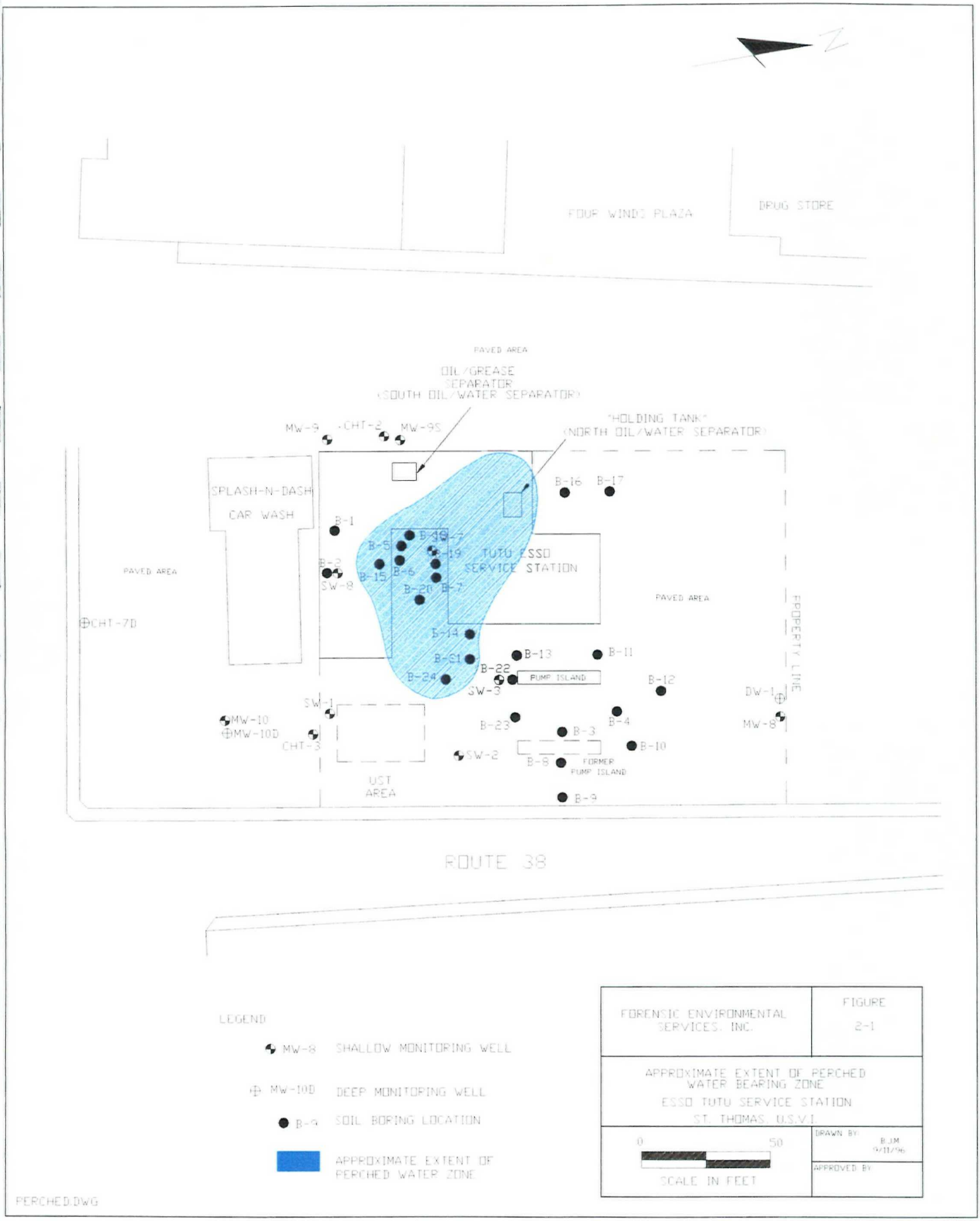
	Estimated Cost
1. Final Remedial Design	$50,000
2. Utility Connections, Permitting	$15,000
3. Installation of G-W/Vapor Recovery Wells	$180,000
4. Installation of Trenching/Piping	$85,000
5. Remedial Treatment System Assembly	$175,000
6. Remedial Treatment System Shipment & Installation	$45,000
7. System Activation - ITP Implementation, 4 months O&M	$80,000
8. UAO/Compliance Reporting	$115,000
TOTAL	$745,000

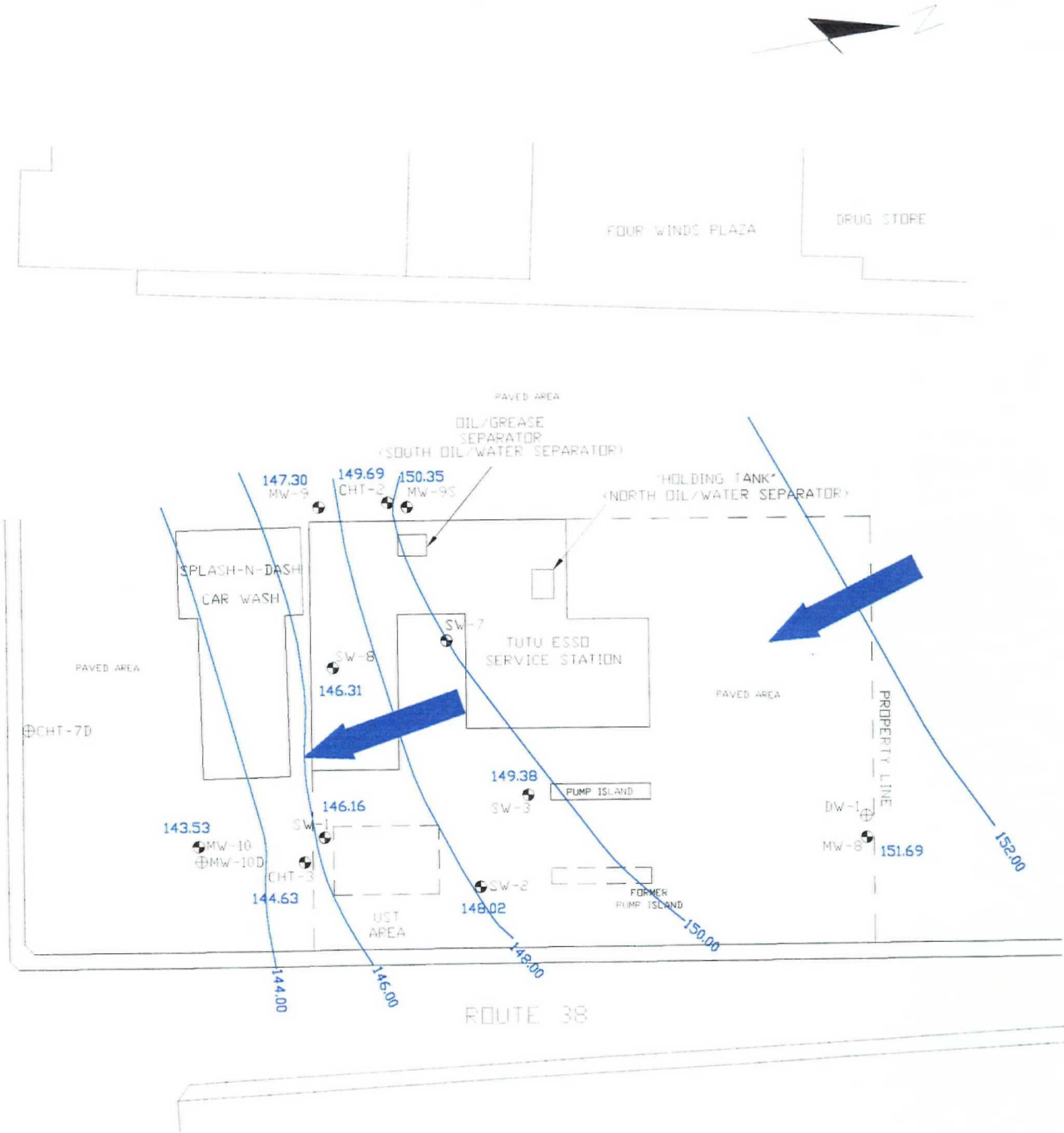
Table 8-2
Construction Implementation Schedule
Tutu Source Control Program
Esso Tutu Service Station
St. Thomas, U.S.V.I.

	Pre-Sept. 1998	September 1998				October 1998				November 1998				December 1998				January 1999				1999
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
1. Submit Final RD Report				■																		
2. Obtain Permits	■	■	■	■	■	■	■															
3. Demolition of Station Buildings	■																					
4. Power Drop at Site				■	■																	
5. Install G-W/Vapor Recovery Wells			■	■			■	■	■													
6. Trenching/Pipe Installation									■	■	■	■										
7. Install Treatment Container Pad									■	■												
8. Order Treatment System Equipment		■	■	■																		
9. Assemble Treatment System Components					■	■	■	■	■													
10. Pre-Shipment Testing of Treatment System										■												
11. Shipment of Treatment System Trailer											■	■	■									
12. Treatment Trailer Installation/Connection														■	■							
13. System Activation - ITP Implementation																■	■	■	■	■	■	■
14. Final System Start-Up																						■

Project delays are expected as a result of the impact of Hurricane Georges. The specific impact on the project schedule cannot presently be fully evaluated.

FIGURES


N
FOUR WINDS PLAZA
DRUG STORE
PAVED AREA
OIL/GREASE SEPARATOR (SOUTH OIL/WATER SEPARATOR)
"HOLDING TANK" (NORTH OIL/WATER SEPARATOR)
MW-9
CHT-2
MW-9S
SPLASH-N-DASH CAR WASH
TUTU ESSO SERVICE STATION
PAVED AREA
PAVED AREA
CHT-7D
B-1
B-2
SW-8
B-5
B-6
B-7
B-15
B-16
B-17
B-19
B-20
B-14
B-21
B-22
B-24
B-13
B-11
B-12
SW-3
PUMP ISLAND
SW-1
MW-10
MW-10D
CHT-3
SW-2
B-23
B-3
B-4
B-8
B-9
B-10
FORMER PUMP ISLAND
UST AREA
DW-1
MW-8
PROPERTY LINE
ROUTE 38
LEGEND
MW-8 SHALLOW MONITORING WELL
MW-10D DEEP MONITORING WELL
B-9 SOIL BORING LOCATION
APPROXIMATE EXTENT OF PERCHED WATER ZONE
FORENSIC ENVIRONMENTAL SERVICES, INC.
FIGURE 2-1
APPROXIMATE EXTENT OF PERCHED WATER BEARING ZONE
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
0
50
SCALE IN FEET
DRAWN BY:
BJM
9/11/96
APPROVED BY:
PERCHED.DWG



LEGEND

SW-7 — SHALLOW MONITORING WELL

DW-1 — DEEP MONITORING WELL

147.30 — GROUND-WATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL

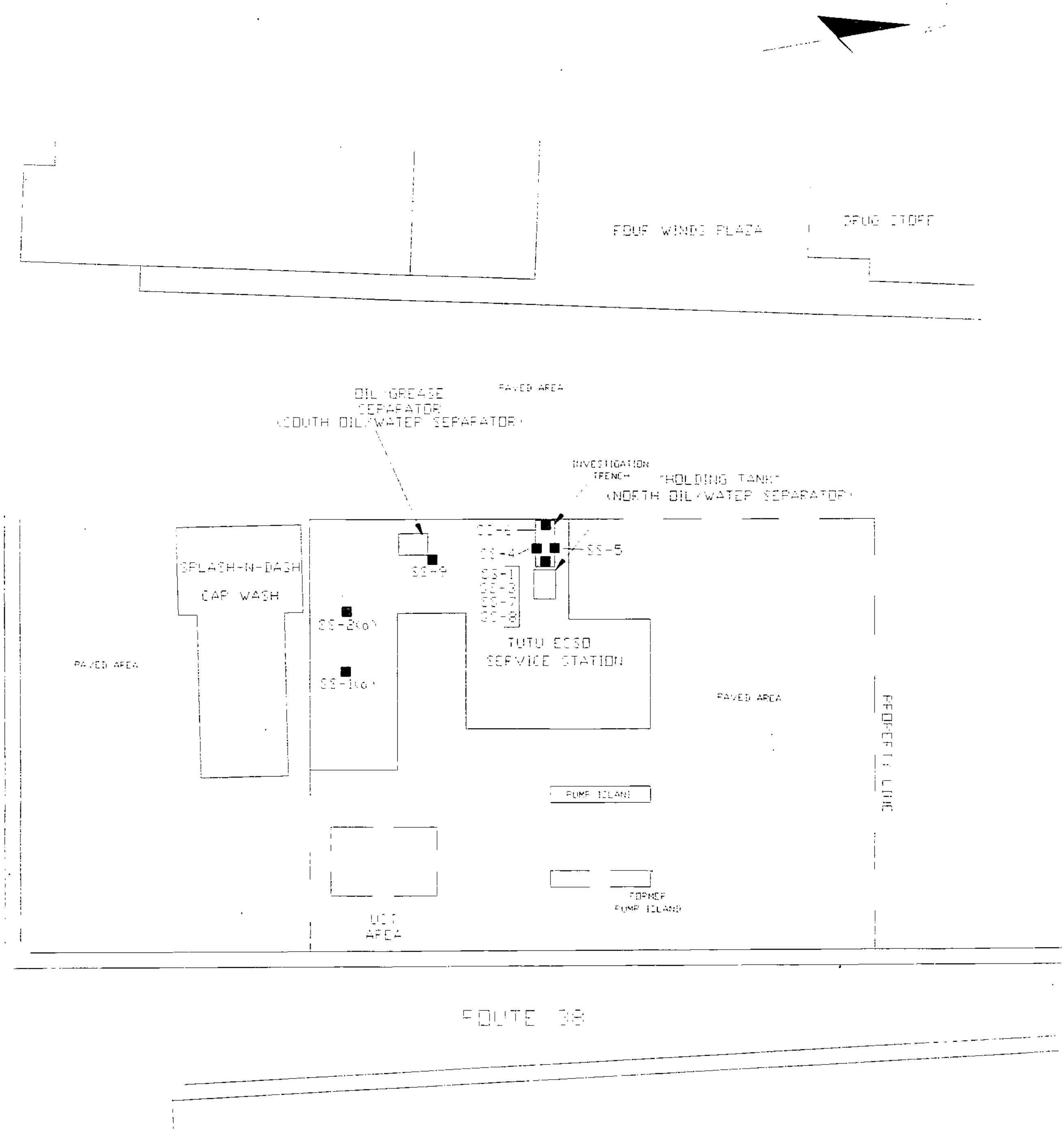
144.00 — GROUND-WATER ELEVATION CONTOUR

GENERAL DIRECTION OF GROUND-WATER FLOW

NOTE: DUE TO THE PRESENCE OF PERCHED WATER CONDITIONS IN THE SOUTHWESTERN PORTION OF THE SITE, DATA FROM SW-7 WAS NOT USED IN THE DEVELOPMENT OF WATER TABLE ELEVATION CONTOURS

FORENSIC ENVIRONMENTAL SERVICES, INC.	FIGURE 2-2
GROUND-WATER FLOW MAP (10/14/96) SHALLOW TUTU AQUIFER ESSO TUTU SERVICE STATION ST. THOMAS, U.S.V.I.	
0 — 50 SCALE IN FEET	DRAWN BY: BJM 9/11/96 APPROVED BY:

GWF1096.DWG



LEGEND

SS-6 ■ SOIL SAMPLE LOCATION

FORENSIC ENVIRONMENTAL SERVICES, INC.

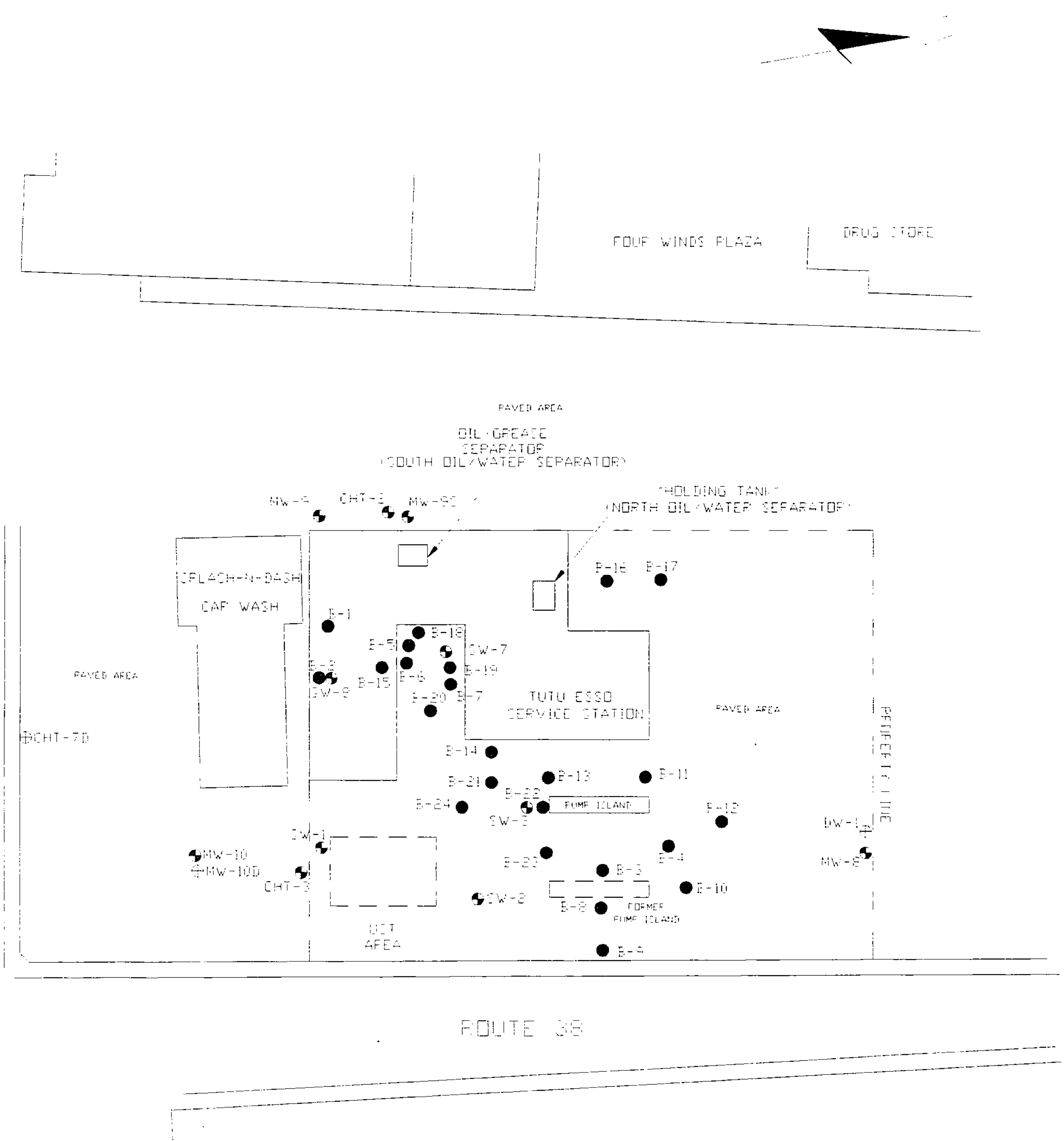
FIGURE 2-3

SAMPLE LOCATION MAP
OIL/WATER SEPARATORS (1993)
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.

0 50
SCALE IN FEET

DRAWN BY:

APPROVED BY:



LEGEND

MW-8 SHALLOW MONITORING WELL

MW-10D DEEP MONITORING WELL

B-9 SOIL BORING LOCATION

FORENSIC ENVIRONMENTAL SERVICES, INC.

FIGURE 2-4

SOIL BORING AND MONITORING WELL LOCATION MAP (1996)
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.

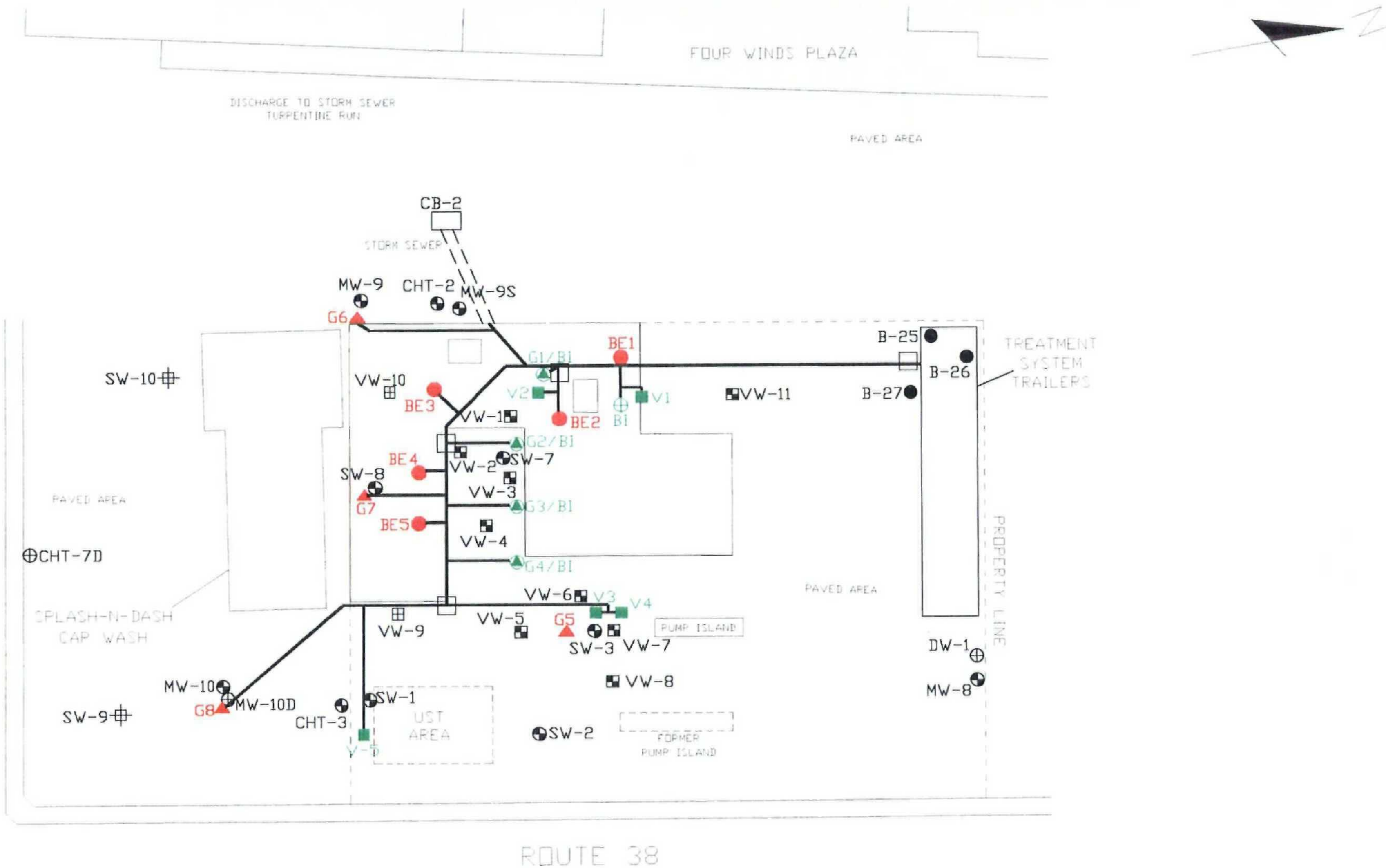
0 50

SCALE IN FEET

DRAWN BY BJM

APPROVED BY

SBMW1996.DWG



LEGEND

VW-8	EXISTING VAPOR MONITORING POINT	V	VAPOR EXTRACTION WELL
VW-9	PROPOSED VAPOR MONITORING POINT	BI	BIOVENTING INJECTION WELL
SW-10	PROPSED MONITORING WELL LOCATION	BE	BIOVENTING EXTRACTION WELL
SW-1	EXISTING MONITORING WELL LOCATION	G8	GROUND-WATER EXTRACTION WELL
B-25	SOIL BORING LOCATION (SEPTEMBER 1998)	G4/BI	GROUND-WATER EXTRACTION WELL CONVERTED TO BIOVENTING INJECTION WELL
			SYSTEM TRENCH

FORENSIC ENVIRONMENTAL SERVICES, INC.

FIGURE 4-1

SOIL AND GROUND-WATER REMEDIATION SYSTEM SCHEMATIC

ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.

0 50
SCALE IN FEET

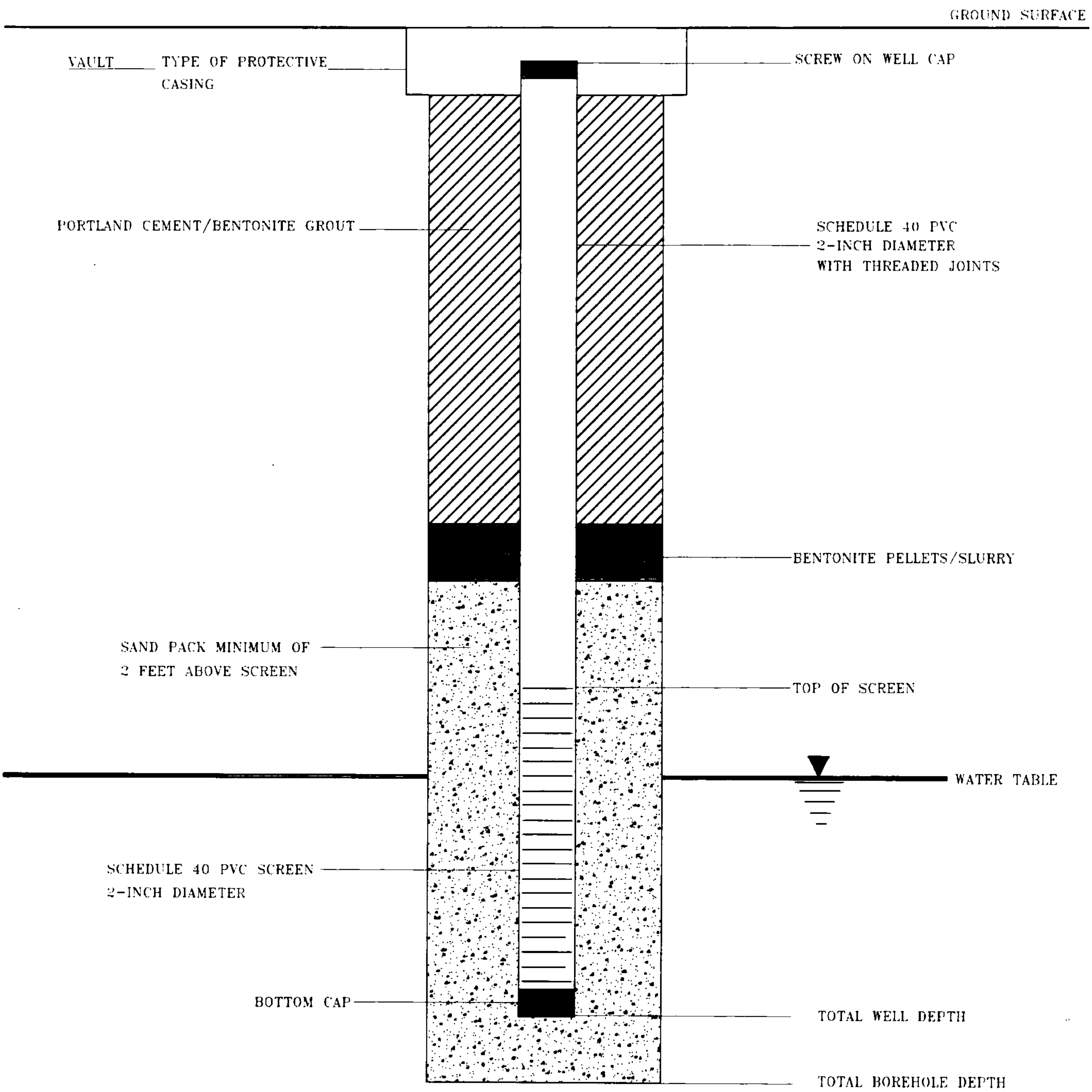
DRAWN BY: BJM 8/11/98

APPROVED BY:

SOILGWRM.DWG

FIGURE 4-2
SOIL VAPOR/BIOVENT EXTRACTION AND BIOVENT INJECTION WELL CONSTRUCTION DIAGRAM

ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.



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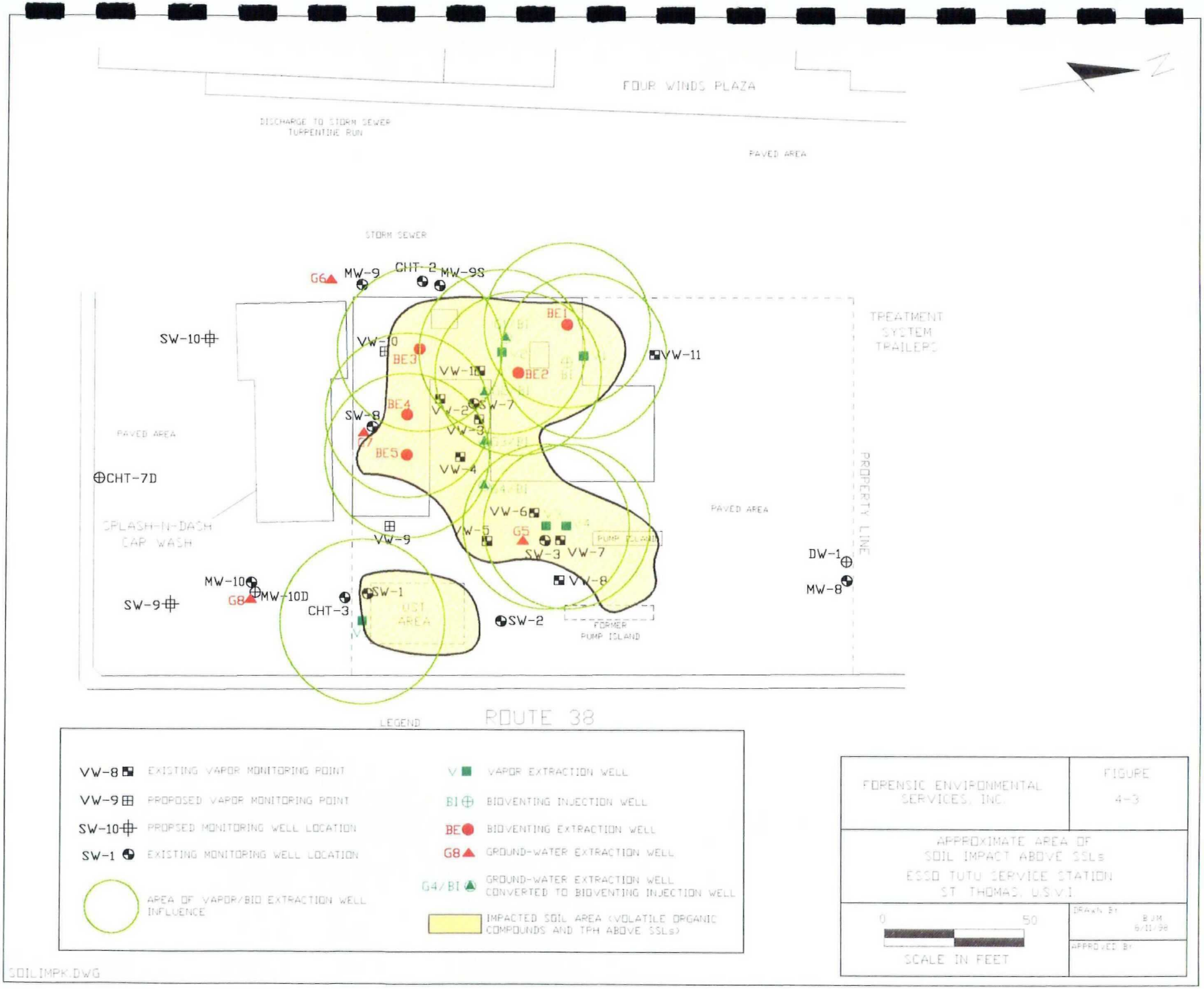
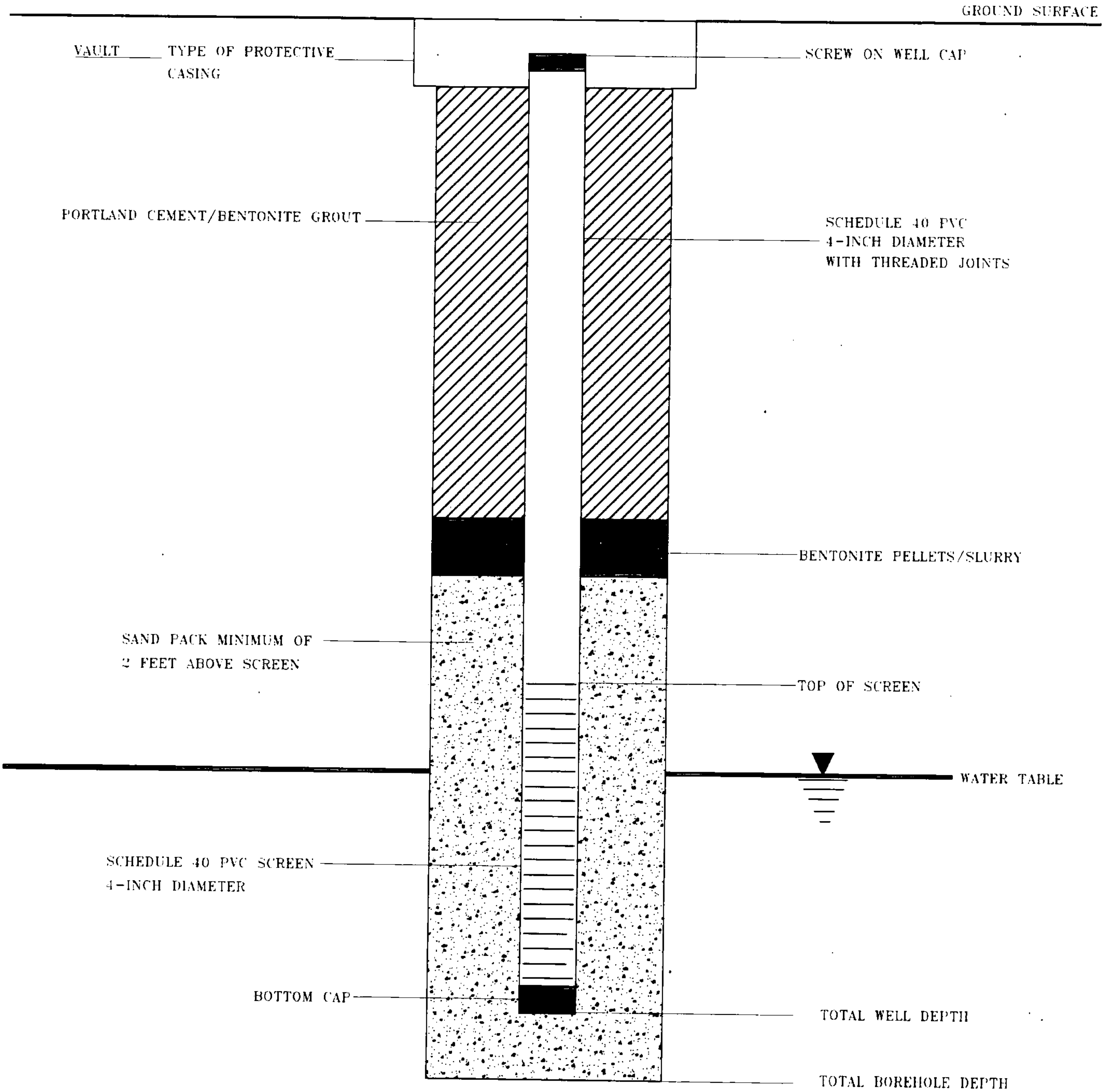

FOUR WINDS PLAZA
DISCHARGE TO STORM SEWER
TURPENTINE RUN
PAVED AREA
STORM SEWER
G6
MW-9
CHT-2
MW-9S
SW-10
VW-10
BE3
BE1
VW-11
VW-1
BE2
TREATMENT
SYSTEM
TRAILERS
SW-8
BE4
VW-2
SW-7
VW-3
G7
BE5
VW-4
PAVED AREA
CHT-7D
SPLASH-N-DASH
CAR WASH
VW-6
VW-5
G5
VW-9
SW-3
VW-7
PAVED AREA
PROPERTY LINE
PUMP ISLAND
DW-1
MW-8
VW-8
MW-10
MW-10D
G8
SW-9
CHT-3
SW-1
UST
AREA
SW-2
FORMER
PUMP ISLAND
ROUTE 38
LEGEND
VW-8 EXISTING VAPOR MONITORING POINT
VW-9 PROPOSED VAPOR MONITORING POINT
SW-10 PROPSED MONITORING WELL LOCATION
SW-1 EXISTING MONITORING WELL LOCATION
AREA OF VAPOR/BIO EXTRACTION WELL INFLUENCE
V VAPOR EXTRACTION WELL
BI BIOVENTING INJECTION WELL
BE BIOVENTING EXTRACTION WELL
G8 GROUND-WATER EXTRACTION WELL
G4/BI GROUND-WATER EXTRACTION WELL CONVERTED TO BIOVENTING INJECTION WELL
IMPACTED SOIL AREA (VOLATILE ORGANIC COMPOUNDS AND TPH ABOVE SSLs)
FORENSIC ENVIRONMENTAL SERVICES, INC.
FIGURE
4-3
APPROXIMATE AREA OF
SOIL IMPACT ABOVE SSLs
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
0
50
SCALE IN FEET
DRAWN BY
BJM
6/11/98
APPROVED BY
SOILIMPK.DWG

FIGURE 4-4

OVERBURDEN GROUND-WATER EXTRACTION/BIOVENT INJECTION WELL CONSTRUCTION DIAGRAM

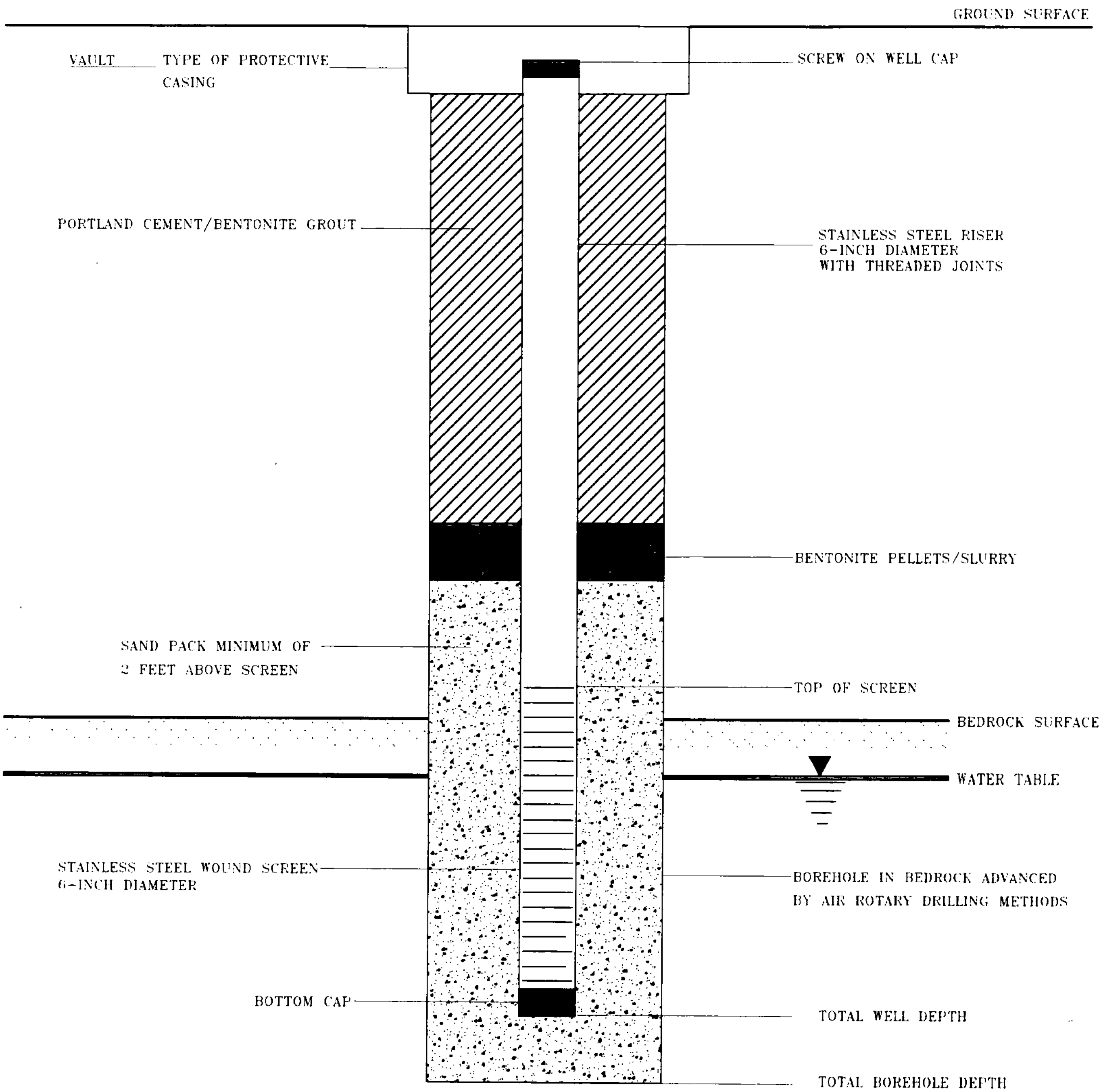
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.



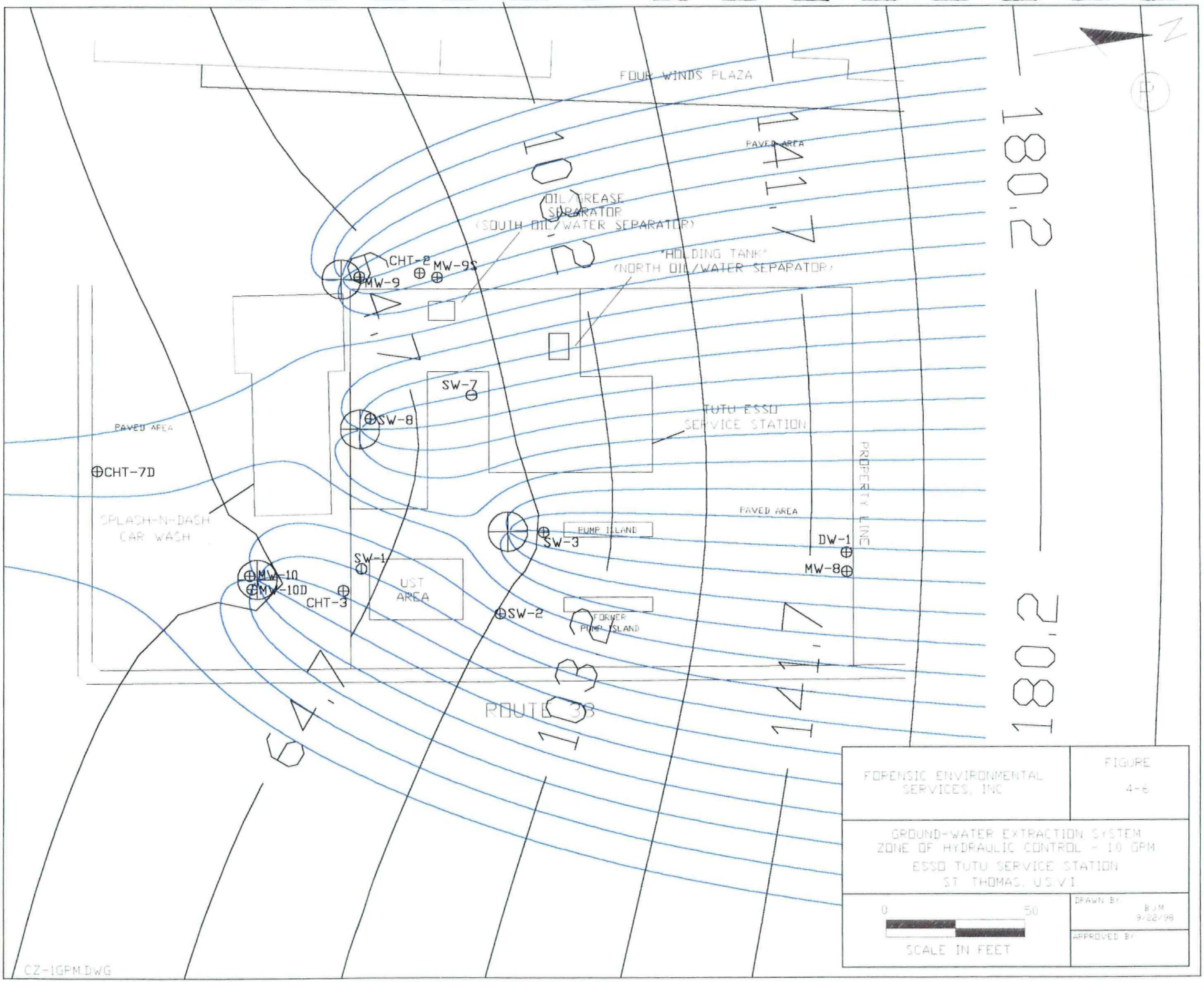
SGWEBI.DWG

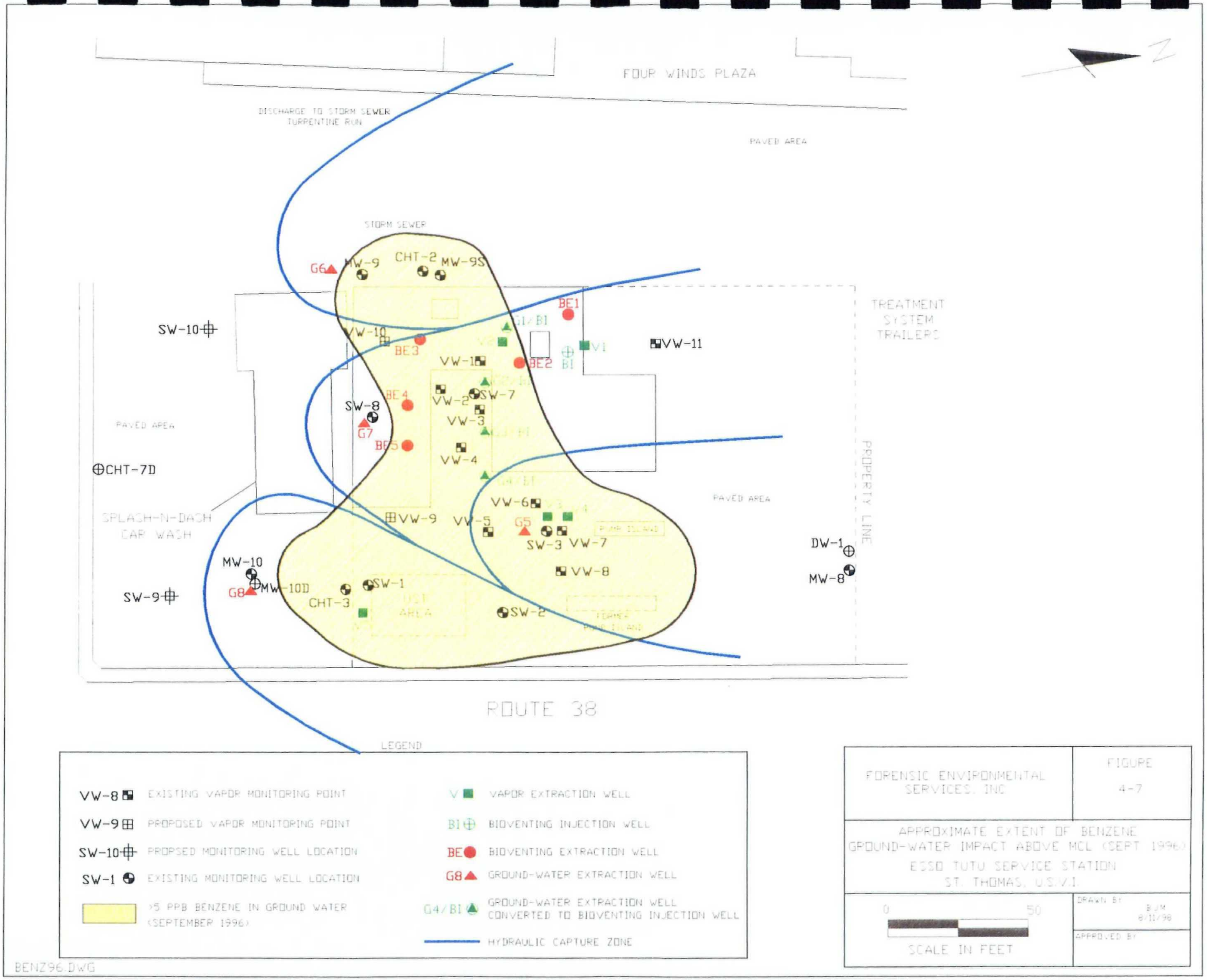
FIGURE 4-5
SHALLOW BEDROCK GROUND-WATER EXTRACTION WELL CONSTRUCTION DIAGRAM

ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.



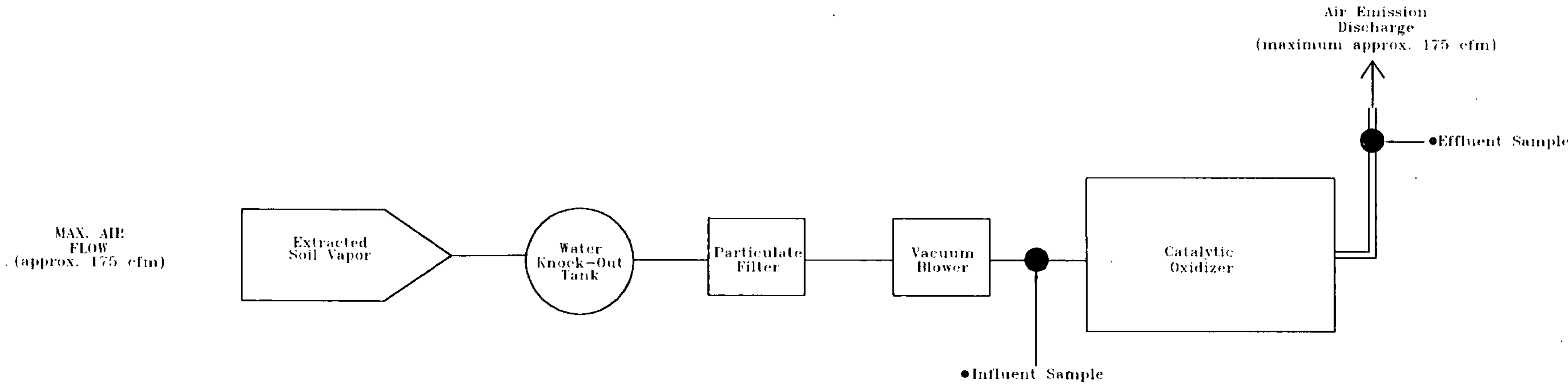
SBRGWE.DWG


N
FOUR WINDS PLAZA
PAVED AREA
180.2
141.7
102
83
64.7
OIL/GREASE SEPARATOR
(SOUTH OIL/WATER SEPARATOR)
"HOLDING TANK"
(NORTH OIL/WATER SEPARATOR)
CHT-2
MW-9S
MW-9
SW-7
SW-8
TUTU ESSO SERVICE STATION
PROPERTY LINE
PAVED AREA
CHT-7D
SPLASH-N-DASH CAR WASH
PUMP ISLAND
SW-3
DW-1
MW-8
SW-1
MW-10
MW-10D
CHT-3
UST AREA
SW-2
FORMER PUMP ISLAND
ROUTE 38
CZ-1GPM.DWG
FORENSIC ENVIRONMENTAL SERVICES, INC.
FIGURE
4-6
GROUND-WATER EXTRACTION SYSTEM
ZONE OF HYDRAULIC CONTROL - 10 GPM
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
0
50
SCALE IN FEET
DRAWN BY:
BJM
9/22/98
APPROVED BY:



FOUR WINDS PLAZA
DISCHARGE TO STORM SEWER TURPENTINE RUN
PAVED AREA
STORM SEWER
G6
MW-9
CHT-2
MW-9S
BE1
G1/BI
V2
V1
BI
VW-11
TREATMENT SYSTEM TRAILERS
SW-10
VW-10
BE3
VW-1
BE2
BE4
VW-2
SW-7
SW-8
VW-3
G7
PAVED AREA
BE5
VW-4
CHT-7D
PROPERTY LINE
VW-6
PAVED AREA
SPLASH-N-DASH CAR WASH
VW-9
VW-5
G5
SW-3
VW-7
DW-1
MW-10
VW-8
MW-8
MW-10D
G8
SW-1
SW-9
CHT-3
UST AREA
SW-2
ROUTE 38
LEGEND
VW-8 EXISTING VAPOR MONITORING POINT
VW-9 PROPOSED VAPOR MONITORING POINT
SW-10 PROPSED MONITORING WELL LOCATION
SW-1 EXISTING MONITORING WELL LOCATION
>5 PPB BENZENE IN GROUND WATER (SEPTEMBER 1996)
V VAPOR EXTRACTION WELL
BI BIOVENTING INJECTION WELL
BE BIOVENTING EXTRACTION WELL
G8 GROUND-WATER EXTRACTION WELL
G4/BI GROUND-WATER EXTRACTION WELL CONVERTED TO BIOVENTING INJECTION WELL
HYDRAULIC CAPTURE ZONE
FORENSIC ENVIRONMENTAL SERVICES, INC
FIGURE 4-7
APPROXIMATE EXTENT OF BENZENE GROUND-WATER IMPACT ABOVE MCL (SEPT 1996)
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
0
50
SCALE IN FEET
DRAWN BY
APPROVED BY
BENZ96.DWG

Figure 7-1
Air Pollution Control
Soil Vapor Flow Diagram
Esso Tutu Service Station

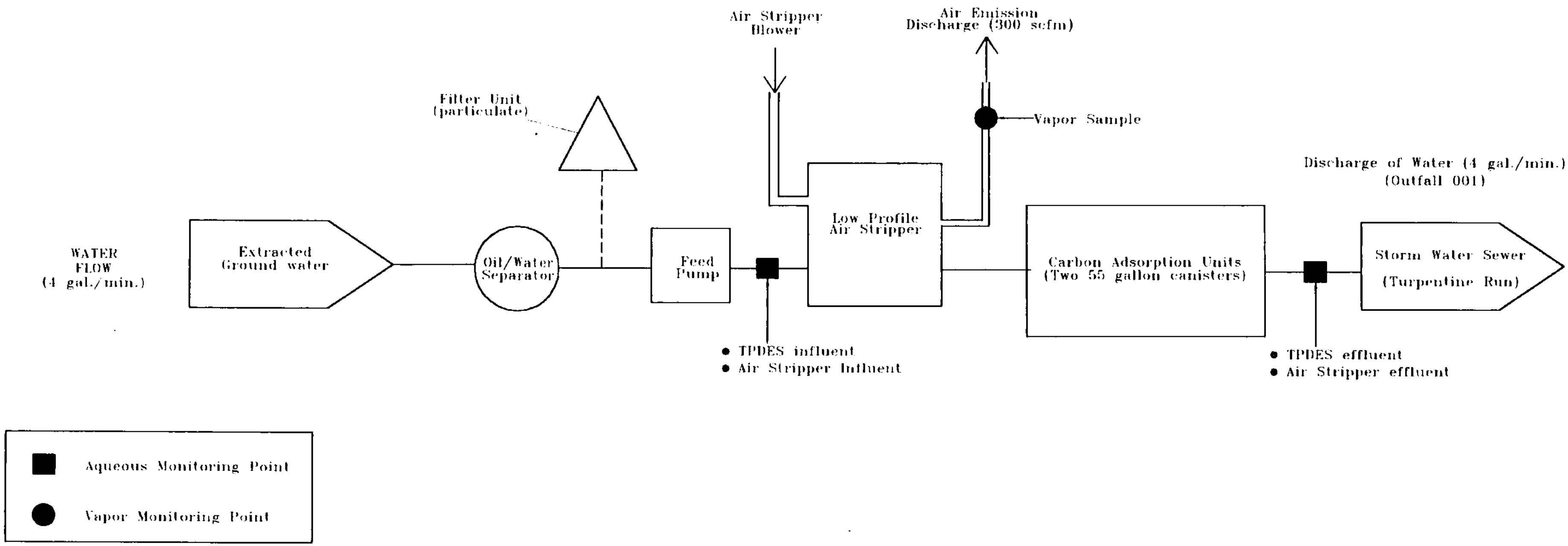


Notes:

1. Influent soil vapors will be sourced from five soil vapor extraction wells and five bioventing wells. Influent soil vapor will be treated by a catalytic oxidation unit.

SVEFLOW.DWG

Figure 7-2
Air Pollution Control
Ground-Water Flow Diagram
Esso Tutu Service Station



Notes:

1. Influent water will be sourced from eight ground-water extraction wells (four overburden, 4 shallow bedrock).

2. Discharge of vapors from the air stripper will occur at a rate of approximately 300 cubic feet per minute (cfm).

TUTULINE.DWG

APPENDIX A
Trenching and Piping Drawings and Specifications

TECHNICAL SPECIFICATIONS FOR ESSO TUTU SERVICE STATION SOIL REMEDIATION PROJECT

HBA #1675

July 22, 1998

HBA Hill & Bell Associates, Inc.
ENGINEERS/CONSULTANTS

262 King Street, Pottstown, PA 19464-5568
610/327-4242

hillbell@bellatlantic.net
FAX 610/970-9407

Technical Specifications
for
Esso Tutu Service Station
Soil Remediation Project

Table of Contents

SECTION 02300 - EARTHWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 QUALITY ASSURANCE

A. Preexcavation Conference: Conduct conference at Project site prior to beginning excavation. Schedule conference with Owner at award of contract.

1.3 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Owner and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Owner not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Owner's written permission.
3. Contact utility-locator service for area where Project is located before excavating.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Free of rock or gravel larger than 3 inches (75 mm) in any dimension, debris, waste, vegetation, and other deleterious matter.

C. Unsatisfactory soils include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Backfill and Fill: Satisfactory soil materials.

E. Subbase: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch (38-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.

F. Base: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95 percent passing a 1-1/2-inch (38-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.2 DEWATERING

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
2. Install a dewatering system to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.

3.3 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavation to subgrade elevations regardless of the character of surface and subsurface conditions encountered, including rock, soil materials, and obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.4 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch (25 mm). Extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavation for Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch (25 mm). Do not disturb bottom of excavations intended for bearing surface.

3.5 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated cross sections, elevations, and grades.

3.6 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

B. Excavate trenches to uniform widths to provide a working clearance on each side of pipe or conduit.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

1. For pipes and conduit, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill.
2. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.7 APPROVAL OF SUBGRADE

A. Notify Owner when excavations have reached required subgrade.

B. If Owner determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Reconstruct subgrades damaged by rain, accumulated water, or construction activities, as directed by Owner.

3.8 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill may be used when approved by Owner.

3.9 STORAGE OF SOIL MATERIALS

A. Specific direction will be provided by the Owner.

3.10 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for record documents.
3. Inspecting and testing underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

3.11 PIPE/CONDUIT TRENCH BACKFILL

A. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

B. Backfill trenches excavated under footings and within 18 inches (450 mm) of bottom of footings; fill with concrete to elevation of bottom of footings.

C. Place and compact initial backfill of subbase material, free of particles larger than 1 inch (25 mm), over the utility pipe or conduit.

1. Carefully compact material under pipe haunches and bring backfill evenly up on both

sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.

D. Coordinate backfilling with utilities testing.

E. Fill voids with approved backfill materials while shoring and bracing, and as sheeting is removed.

F. Place and compact final backfill of satisfactory soil material to final subgrade.

3.12 FILL

A. Preparation: Remove vegetation, topsoil, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface before placing fills.

B. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

3.13 MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill layer before compaction to within 2 percent of optimum moisture content..

1. Remove and replace, or scarify and air-dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.14 COMPACTION OF BACKFILLS AND FILLS

A. Place backfill and fill materials in layers not more than 8 inches (200 mm) in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:

1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches (300 mm) of existing subgrade and each layer of backfill or fill material at 95 percent.

2. Under walkways, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill material at 92 percent.
3. Under lawn or unpaved areas, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill material at 85 percent.

3.15 GRADING

A. General: Uniformly grade areas to a smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Walks: Plus or minus 1 inch (25 mm).
2. Pavements: Plus or minus 1/2 inch (13 mm).

3.16 SUBBASE AND BASE COURSES

A. Under pavements and walks, place subbase course on prepared subgrade and as follows:

1. Place base course material over subbase.
2. Compact subbase and base courses at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.
3. Shape subbase and base to required crown elevations and cross-slope grades.
4. When thickness of compacted subbase or base course is 6 inches (150 mm) or less, place materials in a single layer.
5. When thickness of compacted subbase or base course exceeds 6 inches (150 mm), place materials in equal layers, with no layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick when compacted.

3.17 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.

3.18 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Owner will provide specific direction.

END OF SECTION 02300

SECTION 02751 - CEMENT CONCRETE PAVEMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes exterior cement concrete pavement for the following:

1. Driveways and roadways.
2. Parking lots.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed pavement work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

B. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.

1. Manufacturer must be certified according to the National Ready Mix Concrete Association's Plant Certification Program.

C. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant and each aggregate from one source.

D. ACI Publications: Comply with ACI 301, "Specification for Structural Concrete," unless modified by the requirements of the Contract Documents.

1.4 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic.

PART 2 - PRODUCTS

2.1 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.

1. Use flexible or curved forms for curves of a radius 100 feet (30.5 m) or less.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

2.2 STEEL REINFORCEMENT

A. Plain-Steel Welded Wire Fabric: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

B. Deformed-Steel Welded Wire Fabric: ASTM A 497, flat sheet.

C. Reinforcement Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.

D. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60 (Grade 420), deformed bars; assembled with clips.

E. Plain Steel Wire: ASTM A 82, as drawn.

F. Joint Dowel Bars: Plain steel bars, ASTM A 615/A 615M, Grade 60 (Grade 420). Cut bars true to length with ends square and free of burrs.

G. Tie Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.

H. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcement bars, welded wire fabric, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete or fiber-reinforced concrete of greater compressive strength than concrete, and as follows:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

2.3 CONCRETE MATERIALS

A. General: Use the same brand and type of cementitious material from the same manufacturer throughout the Project.

B. Portland Cement: ASTM C 150, Type I or II.

1. Fly Ash: ASTM C 618, Class F or C.
2. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

C. Aggregate: ASTM C 33, uniformly graded, from a single source.

D. Water: ASTM C 94.

2.4 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) dry.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

E. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:

1. Evaporation Retarder:

a. Cimfilm; Axim Concrete Technologies.
b. Finishing Aid Concentrate; Burke Group, LLC (The).
c. Spray-Film; ChemMasters.
d. Aquafilm; Conspec Marketing & Manufacturing Co., Inc.
e. Sure Film; Dayton Superior Corporation.
f. Eucobar; Euclid Chemical Co.
g. Vapor Aid; Kaufman Products, Inc.
h. Lambco Skin; Lambert Corporation.
i. E-Con; L&M Construction Chemicals, Inc.
j. Confilm; Master Builders, Inc.
k. Waterhold; Metalcrete Industries.
l. Rich Film; Richmond Screw Anchor Co.

m. SikaFilm; Sika Corporation.
n. Finishing Aid; Symons Corporation.
o. Certi-Vex EnvioAssist; Vexcon Chemicals, Inc.

2.5 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.

B. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1752, cork or self-expanding cork.

C. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork.

D. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class and grade to suit requirements, and as follows:

1. Type: Class II, non-load bearing, for bonding freshly mixed to hardened concrete.
2. Type: Class I and II, non-load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

2.6 CONCRETE MIXES

A. Prepare design mixes, proportioned according to ACI 211.1 and ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mixes or field experience.

B. Proportion mixes to provide concrete with the following properties:

1. Compressive Strength (28 Days): 3000 psi (20.7 MPa).
2. Maximum Water-Cementitious Materials Ratio: 0.40
3. Slump Limit: 4 inches (100 mm).

C. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

1. Fly Ash: 25 percent.
2. Combined Fly Ash and Pozzolan: 25 percent.
3. Ground Granulated Blast-Furnace Slag: 50 percent.
4. Combined Fly Ash or Pozzolan, and Ground Granulated Blast-Furnace Slag: 50

percent portland cement minimum, with fly ash or pozzolan not exceeding 25 percent.

2.7 CONCRETE MIXING

A. Ready-Mixed Concrete: Comply with requirements and with ASTM C 94 and ASTM C 1116.

1. When air temperature is between 85 deg F (30 deg C) and 90 deg F (32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Comply with requirements and measure, batch, and mix concrete materials and concrete according to ASTM C 94. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For mixers of 1 cu. yd. (0.76 cu. m) or smaller capacity, continue mixing at least one and one-half minutes, but not more than five minutes after ingredients are in mixer, before any part of batch is released.
2. For mixers of capacity larger than 1 cu. yd. (0.76 cu. m), increase mixing time by 15 seconds for each additional 1 cu. yd. (0.76 cu. m).
3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mix type, mix time, quantity, and amount of water added.

PART 3 - EXECUTION

3.1 PREPARATION

A. Proof-roll prepared subbase surface to check for unstable areas and verify need for additional compaction. Proceed with pavement only after nonconforming conditions have been corrected and subgrade is ready to receive pavement.

B. Remove loose material from compacted subbase surface immediately before placing concrete.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form release agent to ensure separation from concrete without damage.

3.3 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating reinforcement and with recommendations in CRSI's "Placing Reinforcing Bars" for placing and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.

C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

D. Install welded wire fabric in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

E. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch (50-mm) overlap to adjacent mats.

3.4 JOINTS

A. General: Construct construction, isolation, and contraction joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline, unless otherwise indicated.

1. When joining existing pavement, place transverse joints to align with previously placed joints, unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour, unless pavement terminates at isolation joints.

1. Provide preformed galvanized steel or plastic keyway-section forms or bulkhead forms with keys, unless otherwise indicated. Embed keys at least 1-1/2 inches (38 mm) into concrete.
2. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of pavement strips, unless otherwise indicated.
3. Provide tie bars at sides of pavement strips where indicated.

4. Use epoxy bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.

1. Locate expansion joints at intervals of 50 feet (15.25 m), unless otherwise indicated.
2. Extend joint fillers full width and depth of joint.
3. Terminate joint filler less than 1/2 inch (12 mm) or more than 1 inch (25 mm) below finished surface if joint sealant is indicated.
4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
6. Protect top edge of joint filler during concrete placement with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt-coat one-half of dowel length to prevent concrete bonding to one side of joint.

E. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with groover tool to the following radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.

2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (3-mm-) wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.

F. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to the following radius. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.

3.5 CONCRETE PLACEMENT

A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcement steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.

B. Moisten subbase to provide a uniform dampened condition at the time concrete is placed. Do not place concrete around manholes or other structures until they are at the required finish elevation and alignment.

C. Comply with requirements and with recommendations in ACI 304R for measuring, mixing, transporting, and placing concrete.

D. Do not add water to concrete during delivery, at Project site, or during placement.

E. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

F. Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures to consolidate concrete according to recommendations in ACI 309R.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand-spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.

G. Place concrete in two operations; strike off initial pour for entire width of placement and to the required depth below finish surface. Lay welded wire fabric or fabricated bar mats immediately in final position. Place top layer of concrete, strike off, and screed.

1. Remove and replace portions of bottom layer of concrete that have been placed more than 15 minutes without being covered by top layer, or use bonding agent if approved by Owner.

H. Screed pavement surfaces with a straightedge and strike off. Commence initial floating using bull floats or darbies to form an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading dry-shake surface treatments.

I. Hot-Weather Placement: Place concrete according to recommendations in ACI 305R and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90 deg F (32 deg C). Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover reinforcement steel with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.

3. Fog-spray forms, reinforcement steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.6 CONCRETE FINISHING

A. General: Wetting of concrete surfaces during screeding, initial floating, or finishing operations is prohibited.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and the concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots, and fill low spots. Refloat surface immediately to uniform granular texture.

1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.

3.7 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and follow recommendations in ACI 305R for hot-weather protection during curing.

B. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Begin curing after finishing concrete, but not before free water has disappeared from concrete surface.

D. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:

1. Moisture Curing: Keep surfaces continuously moist for not less than three days with the following materials:

a. Water.
b. Continuous water-fog spray.
c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining

cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.8 PAVEMENT TOLERANCES

A. Comply with tolerances of ACI 117 and as follows:

1. Elevation: 1/4 inch (6 mm).
2. Thickness: Plus 3/8 inch (9 mm), minus 1/4 inch (6 mm).
3. Surface: Gap below 10-foot- (3-m-) long, unleveled straightedge not to exceed 1/4 inch (6 mm).
4. Lateral Alignment and Spacing of Tie Bars and Dowels: 1 inch (25 mm).
5. Vertical Alignment of Tie Bars and Dowels: 1/4 inch (6 mm).
6. Alignment of Tie-Bar End Relative to Line Perpendicular to Pavement Edge: 1/2 inch (13 mm).
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Pavement Edge: Length of dowel 1/4 inch per 12 inches (6 mm per 300 mm).
8. Joint Spacing: 3 inches (75 mm).
9. Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.
10. Joint Width: Plus 1/8 inch (3 mm), no minus.

3.9 REPAIRS AND PROTECTION

A. Remove and replace concrete pavement that is broken, damaged, or defective, or does not meet requirements in this Section.

B. Drill test cores where directed by Owner when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with portland cement concrete bonded to pavement with epoxy adhesive.

C. Protect concrete from damage. Exclude traffic from pavement for at least 3 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial

Completion inspections.

END OF SECTION 02751

SECTION 03301 - CAST-IN-PLACE CONCRETE (LIMITED APPLICATIONS)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUBMITTALS

A. General: In addition to the following, comply with submittal requirements in ACI 301.

B. Product Data: For each type of manufactured material and product indicated.

C. Design Mixes: For each concrete mix.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has completed concrete work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

B. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.

C. Source Limitations: Obtain each type of cement of the same brand from the same manufacturer's plant, each aggregate from one source, and each admixture from the same manufacturer.

D. Comply with ACI 301, "Specification for Structural Concrete," including the following, unless modified by the requirements of the Contract Documents.

1. General requirements, including submittals, quality assurance, acceptance of structure, and protection of in-place concrete.
2. Formwork and form accessories.
3. Steel reinforcement and supports.
4. Concrete mixtures.
5. Handling, placing, and constructing concrete.

PART 2 - PRODUCTS

2.1 FORMWORK

A. Furnish formwork and form accessories according to ACI 301.

2.2 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.

B. Plain-Steel Wire: ASTM A 82, as drawn.

C. Plain-Steel Welded Wire Fabric: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

D. Deformed-Steel Welded Wire Fabric: ASTM A 497, flat sheet.

2.3 CONCRETE MATERIALS

A. Portland Cement: ASTM C 150, Type I.

B. Normal-Weight Aggregate: ASTM C 33, uniformly graded, not exceeding 1-1/2-inch (38-mm) nominal size.

C. Water: Potable and complying with ASTM C 94.

2.4 RELATED MATERIALS

A. Fine-Graded Granular Material: Clean mixture of crushed stone, crushed gravel, and manufactured or natural sand; ASTM D 448, Size 10, with 100 percent passing a No. 4 (4.75-mm) sieve and 10 to 30 percent passing a No. 100 (0.15-mm) sieve; complying with deleterious substance limits of ASTM C 33 for fine aggregates.

B. Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D 1752, cork or self-expanding cork.

2.5 CURING MATERIALS

A. Water: Potable.

2.6 CONCRETE MIXES

A. Comply with ACI 301 requirements for concrete mixtures.

B. Prepare design mixes, proportioned according to ACI 301, for normal-weight concrete determined by either laboratory trial mix or field test data bases, as follows:

1. Compressive Strength (28 Days): 3000 psi (20.7 MPa).
2. Slump: not more than 4 inches (100 mm).

2.7 CONCRETE MIXING

A. Ready-Mixed Concrete: Comply with ASTM C 94 and ASTM C 1116.

1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For mixer capacity of 1 cu. yd. (0.76 cu. m) or smaller, continue mixing at least one and one-half minutes, but not more than five minutes after ingredients are in mixer, before any part of batch is released.
2. For mixer capacity larger than 1 cu. yd. (0.76 cu. m), increase mixing time by 15 seconds for each additional 1 cu. yd. (0.76 cu. m).
3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mix type, mix time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.1 FORMWORK

A. Design, construct, erect, shore, brace, and maintain formwork according to ACI 301.

3.2 STEEL REINFORCEMENT

A. Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

3.3 JOINTS

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

B. Construction Joints: Locate and install so as not to impair strength or appearance of concrete.

C. Contraction (Control) Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with groover tool to a radius of 1/8 inch (3 mm). Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.
2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (3-mm-) wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

3.4 CONCRETE PLACEMENT

A. Comply with recommendations in ACI 304R for measuring, mixing, transporting, and placing concrete.

B. Do not add water to concrete during delivery, at Project site, or during placement.

C. Consolidate concrete with mechanical vibrating equipment.

3.5 FINISHING FORMED SURFACES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defective areas repaired and patched, and fins and other projections exceeding 1/4 inch (6 mm) in height rubbed down or chipped off.

1. Apply to concrete surfaces not exposed to public view.

B. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces, unless otherwise indicated.

3.6 FINISHING UNFORMED SURFACES

A. General: Comply with ACI 302.1R for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

B. Screed surfaces with a straightedge and strike off. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane before excess moisture or bleedwater appears on the surface.

1. Do not further disturb surfaces before starting finishing operations.

C. Trowel Finish: Apply a hard trowel finish to surfaces to be covered with thin film-finish coating system.

3.7 TOLERANCES

A. Comply with ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."

3.8 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection, and follow recommendations in ACI 305R for hot-weather protection during curing.

B. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Begin curing after finishing concrete, but not before free water has disappeared from concrete surface.

D. Curing Methods: Cure formed and unformed concrete for at least seven days by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

   a. Water.
   b. Continuous water-fog spray.
   c. Absorptive cover, water saturated and kept continuously wet. Cover concrete

surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

3.9 REPAIRS

A. Remove and replace concrete that does not comply with requirements in this Section.

END OF SECTION 03301

SECTION 15050 - BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following basic mechanical materials and methods to complement other Division 15 Sections.

1. Piping materials and installation instructions common to most piping systems.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and prevent entrance of dirt, debris, and moisture.

B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, if stored inside.

C. Protect flanges, fittings, and piping specialties from moisture and dirt.

D. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.4 SEQUENCING AND SCHEDULING

A. Coordinate mechanical equipment installation with other building components.

B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction to allow for mechanical installations.

C. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work.

D. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

PART 2 - EXECUTION

2.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. General: Install piping as described below, unless piping Sections specify otherwise. Individual Division 15 piping Sections specify unique piping installation requirements.

B. General Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, unless deviations to layout are approved on Coordination Drawings.

C. Install piping at indicated slope.

D. Install components with pressure rating equal to or greater than system operating pressure.

E. Install piping free of sags and bends.

F. Install fittings for changes in direction and branch connections.

G. Install couplings according to manufacturer's written instructions.

H. Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping specification Sections:

1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

    a. Note internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
    b. Apply appropriate tape or thread compound to external pipe threads, unless dry seal threading is specified.
    c. Align threads at point of assembly.
    d. Tighten joint with wrench. Apply wrench to valve end into which pipe is being

threaded.

e. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

4. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join pipe and fittings according to the following:

   a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   b. PVC Pressure Piping: ASTM D 2672.
   c. PVC Nonpressure Piping: ASTM D 2855.

END OF SECTION 15050

SECTION 15100 - VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each valve type. Include body material, valve design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions. Include list indicating valve and its application.

1.3 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.

B. MSS Compliance: Comply with the various MSS Standard Practice documents referenced.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set ball valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store indoors and maintain valve temperature higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight

enclosures.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. Valves:
   a. Conbraco Industries, Inc.; Apollo Division.
   b. Hammond Valve Corporation.
   c. Milwaukee Valve Company, Inc.
   d. NIBCO Inc.
   e. Stockham Valves & Fittings, Inc.
   f. Tyler Pipe.
   g. Victaulic Company of America.
   h. Chemtrol.
   i. George Fischer, Inc..
   j. Hayward industrial Products, Inc.
   k. Sloane: R & G Sloane Manufacturing Co., Inc.

2.2 BASIC, COMMON FEATURES

A. Pressure and Temperature Ratings: As indicated in the "Application Schedule" of Part 3 of this Section and as required to suit system pressures and temperatures.

B. Sizes: Same size as upstream pipe, unless otherwise indicated.

C. Threads: ASME B1.20.1.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION

A. Install valves as indicated, according to manufacturer's written instructions.

B. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above the center of the pipe.

E. Install valves in a position to allow full stem movement.

3.3 APPLICATION SCHEDULE

A. General Application: Use ball valves for shutoff duty and for throttling duty. Refer to piping system Specification Sections for specific valve applications and arrangements.

1. Ball Valves: 150 psi @ 75 deg., viton O ring seals, full port design, socket cement ends.

3.4 ADJUSTING

A. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

END OF SECTION 15100

SECTION 15411 - PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SYSTEM PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing piping systems with the following minimum working-pressure ratings, unless otherwise indicated:

1. Carrier & Drain Piping: unpressureized
2. Bioinjection Piping: 150 psig (1100 kPa).
3. Biovent & Vapor Extraction Piping: 32" hg. Vacuum
4. Air & Water Hose: 150 psig (690 kPa).

1.3 SUBMITTALS

A. Specification sheets indicating pressure rating of materials.

1.4 QUALITY ASSURANCE

A. Provide listing/approval stamp, label, or other marking on piping made to specified standards.

B. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

C. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic piping components.

PART 2 - PRODUCTS

2.1 PIPES AND TUBES

A. General: Applications of the following pipe and tube materials are indicated in Part 3 "Piping Applications" Article.

B. PVC Plastic Pipe: ASTM D 1785, Schedules 40 and 80.

C. PVC Plastic Pipe: AWWA C900, Classes 150 and 200; with bell end with gasket, and spigot end.

2.2 PIPE AND TUBE FITTINGS

A. General: Applications of the following pipe and tube fitting materials are indicated in Part 3 "Piping Applications" Article.

B. Schedule 80, PVC Socket Fittings: ASTM D 2467.

C. Schedule 40, PVC Socket Fittings: ASTM D 2466.

D. Schedule 80, PVC Threaded Fittings: ASTM D 2464.

E. PVC Gasketed Fittings: AWWA C907, Class 150; with gaskets.

2.3 JOINING MATERIALS

A. General: Applications of the following piping joining materials are indicated in Part 3 "Piping Applications" Article.

2.4 VALVES

A. Refer to Division 15 Section "Valves" for general-duty valves.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 2 Section "Earthwork" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below, unless otherwise indicated.

B. Carrier Piping: Use the following:

1. PVC, Schedule 40 pipe; PVC, Schedule 40 fittings; and solvent-cemented joints.

C. Bioinjection, Bioextraction, & Vapor Extraction Piping: Use the following:

1. PVC, Schedule 80 pipe; PVC, Schedule 80 fittings; and solvent-cemented joints

D. Drain Piping: Use the following:

1. PVC, DWV pipe ; PVC, DWV fittings; and solvent-cemented joints

E. Air & Water Hose: Use the following:

1. PVC, 150 PSI rated, with hose barb fittings secure with stainless steel screwed worm drive clamps. Use quick connects, Twin-Kam Kamlok Couplers as manufactured by OPW or approved equal, consisting of a brass adapter hose shank and coupler hose shank at each pull station and well vault as indicated.

3.3 JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Mechanical Materials and Methods" for basic piping joint construction.

B. Solvent-Cemented, Thermoplastic Pipe and Fitting Joints: Handle cleaners, primers, and solvent cements according to ASTM F 402.

3.4 FIELD QUALITY CONTROL

A. Inspect piping as follows:

1. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
2. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

    a. Roughing-In Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
    b. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

3. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having

jurisdiction.

B. Test piping as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
3. Cap and subject piping to static pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Leaks and loss in test pressure constitute defects that must be repaired.
4. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

END OF SECTION 15411

Mechanical/Electrical Bill of Materials

ITEM	QUANTITY	SUPPLIED BY	INSTALLED BY
4" sch. 40 PVC pipe	1550 lf	Contractor	Contractor
couplings	150	"	"
45 deg elb.	22	"	"
90 deg elb	2	"	"
3" PVC DWV pipe	350 lf	"	"
couplings	35	"	"
90 deg elb	1	"	"
45 deg elb	3	"	"
cap	1	"	"
4" sch 80 PVC pipe	120 lf	"	"
couplings	12	"	"
4" T	4	"	"
90 deg elb	1	"	"
45 deg elb	1	"	"
3" sch 80 PVC pipe	350 lf	"	"
couplings	35	"	"
3" T	12	"	"
45 deg elb	6	"	"
2" sch 80 PVC pipe	250 lf	"	"
couplings	25	"	"
45 deg elb	17	"	"
2"T	10	"	"
1 1/2" sch 80 PVC pipe	150 lf	"	"
couplings	15	"	"
45 deg elb	12	"	"
1 1/2" T	10	"	"
1" PVC pipe	30 lf	"	"
90 deg elb	30	"	"
Sch 80 fittings			
2 x 11/2 reducer	2	"	"
3 x 2 reducer	3	"	"
4 x 3 reducer	1	"	"
2 x 1 reducer	10	"	"
1 ½ x 1 reducer	20	"	"
1 x 1/4 reducer	15	"	"
4 x 4 x 2 T	2	"	"
3 x 3 x 2 T	1	"	"
3 x 3 x 1 ½ T	4	"	"
2 x 2 x 1 ½ T	4	"	"
1" thd x socket adapter	30	"	"

ITEM	QUANTITY	SUPPLIED BY	INSTALLED BY
3/4" PVC hose	3450 lf	Contractor	Contractor
3/4" quick connects	64	"	"
Valves			
2" Tru-union	5	"	"
1 1/2" Tru-union	10	"	"
1/4" Brass 3-way	15	"	"
Propane Pipe	---	Others	Others
3" Rigid Galvanized PVC Conduit	90 lf	Contractor	Contractor
4"x 4"x 4" NEMA 3R enclosure	2	Contractor	Contrractor
Flow Meters with 1" connectors	15	Others	Contractor
Pressure/vacuum gauges sample ports	15	Others	Others
All well caps and down well materials	---	Others	Others
Well Vaults*	19	Others	Others
Chain link fencing	220 lf	Contractor	Contractor
Posts	23	Contractor	Contractor
Locking mechanisms	1	Contractor	Contractor
Padlocks	---	Others	Others
Sea Box Anchor Bolts	8 - 1 1/2" dia.	Contractor	Contractor
Propane Tank Anchor Bolts	4 - 1" dia. Expansion Bolts	Contractor	Others

NOTE:

1. * - Contractor will cut steel skirts in vaults to allow for piping penetration.
2. This Bill of Material list is for bidding purposes only. Contractor is responsible to furnish and install all necessary materials for a complete installation. Contractor is responsible for determining material quantities to suit the field conditions.
3. Full size T's with appropriate reducing bushings may be used in lieu of reducing T's.

Mechanical/Electrical Bill of Materials

ITEM	QUANTITY	SUPPLIED BY	INSTALLED BY
4" sch. 40 PVC pipe	1550 lf	Contractor	Contractor
couplings	150	"	"
45 deg elb.	22	"	"
90 deg elb	2	"	"
3" PVC DWV pipe	350 lf	"	"
couplings	35	"	"
90 deg elb	1	"	"
45 deg elb	3	"	"
cap	1	"	"
4" sch 80 PVC pipe	120 lf	"	"
couplings	12	"	"
4" T	4	"	"
90 deg elb	1	"	"
45 deg elb	1	"	"
3" sch 80 PVC pipe	350 lf	"	"
couplings	35	"	"
3" T	12	"	"
45 deg elb	6	"	"
2" sch 80 PVC pipe	250 lf	"	"
couplings	25	"	"
45 deg elb	17	"	"
2"T	10	"	"
1 1/2" sch 80 PVC pipe	150 lf	"	"
couplings	15	"	"
45 deg elb	12	"	"
1 1/2" T	10	"	"
1" PVC pipe	30 lf	"	"
90 deg elb	30	"	"
Sch 80 fittings			
2 x 11/2 reducer	2	"	"
3 x 2 reducer	3	"	"
4 x 3 reducer	1	"	"
2 x 1 reducer	10	"	"
1 ½ x 1 reducer	20	"	"
1 x 1/4 reducer	15	"	"
4 x 4 x 2 T	2	"	"
3 x 3 x 2 T	1	"	"
3 x 3 x 1 ½ T	4	"	"
2 x 2 x 1 ½ T	4	"	"
1" thd x socket adapter	30	"	"

ITEM	QUANTITY	SUPPLIED BY	INSTALLED BY
3/4" PVC hose	3450 lf	Contractor	Contractor
3/4" quick connects	64	"	"
Valves			
2" Tru-union	5	"	"
1 1/2" Tru-union	10	"	"
1/4" Brass 3-way	15	"	"
Propane Pipe	---	Others	Others
3" Rigid Galvanized PVC Conduit	90 lf	Contractor	Contractor
4"x 4"x 4" NEMA 3R enclosure	2	Contractor	Contrractor
Flow Meters with 1" connectors	15	Others	Contractor
Pressure/vacuum gauges sample ports	15	Others	Others
All well caps and down well materials	---	Others	Others
Well Vaults*	19	Others	Others
Chain link fencing	220 lf	Contractor	Contractor
Posts	23	Contractor	Contractor
Locking mechanisms	1	Contractor	Contractor
Padlocks	---	Others	Others
Sea Box Anchor Bolts	8 - 1 1/2" dia.	Contractor	Contractor
Propane Tank Anchor Bolts	4 - 1" dia. Expansion Bolts	Contractor	Others

NOTE:

1. * - Contractor will cut steel skirts in vaults to allow for piping penetration.
2. This Bill of Material list is for bidding purposes only. Contractor is responsible to furnish and install all necessary materials for a complete installation. Contractor is responsible for determining material quantities to suit the field conditions.
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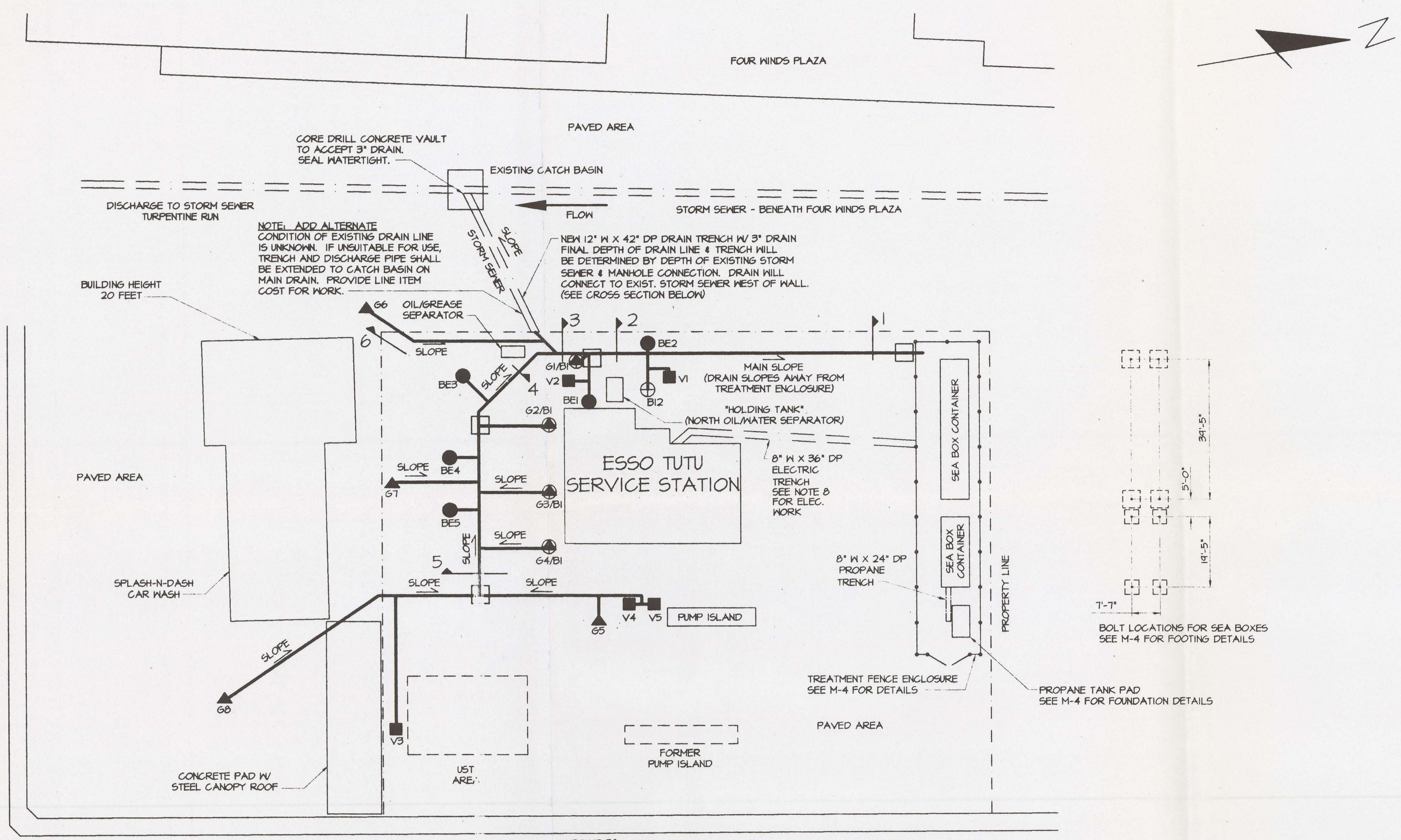
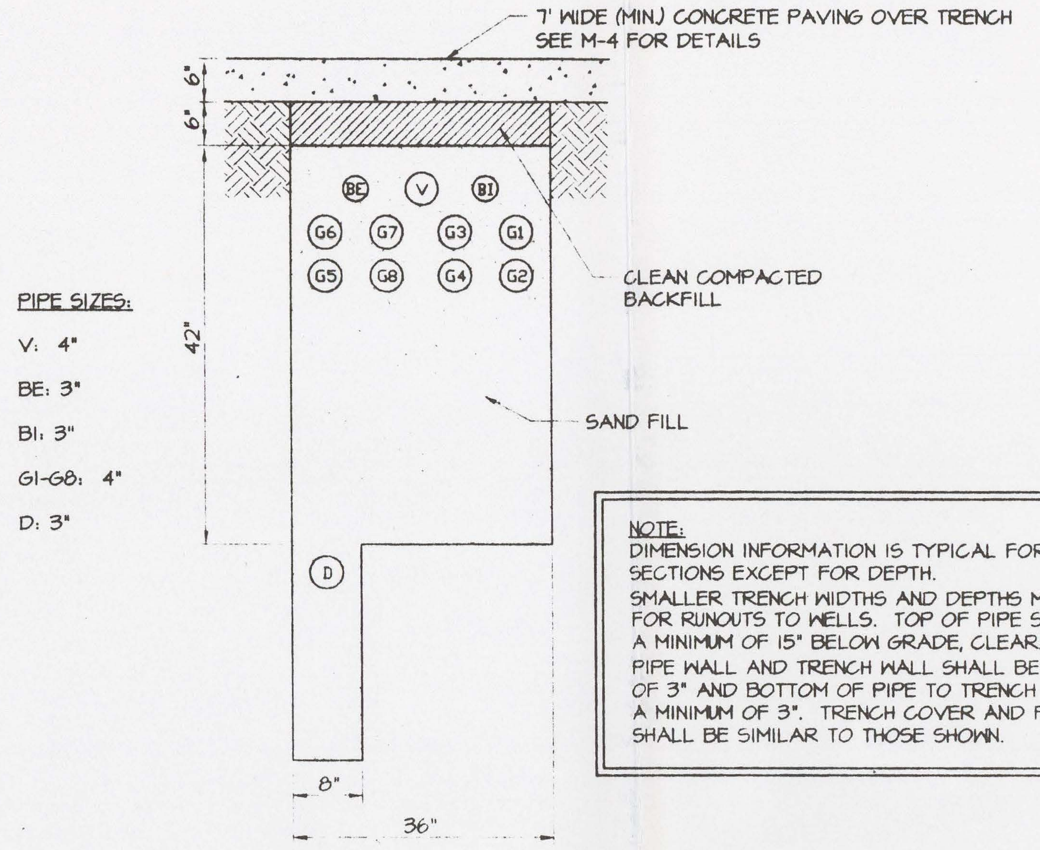


TRENCH PLAN

SCALE: 1" = 20'-0"

NOTES:

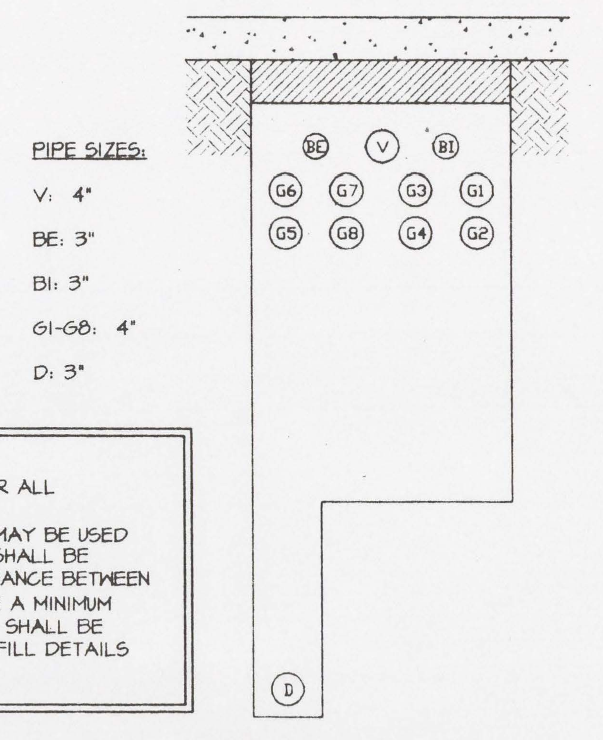
1. SLOPE ALL LINES TO PULL STATIONS. SLOPE SHALL BE 1/8" PER FOOT.
2. ALL 4" G# LINES CONTAIN A 3/4" AIR HOSE AND 3/4" WATER HOSE.
3. TRENCH DEPTH : 42" UNLESS OTHERWISE NOTED
4. 4" G CARRIER PIPES: PVC SCH. 40 W/ SOLVENT JOINT FITTINGS SOLVENT CEMENT ALL FITTINGS & PRESSURE TEST PIPE
5. AIR & WATER HOSE: 3/4 I.D. PVC, 150 PSI WORKING PRESSURE. BARBED END FITTINGS WITH STAINLESS STEEL WORM DRIVE CLAMPS
6. BI, BE, & V PIPING: PVC SCHEDULE 80 WITH SOLVENT JOINT FITTINGS. SOLVENT WELD CEMENT FITTINGS & PRESSURE TEST PIPE
7. ALL PULL STATIONS SHALL BE SEALED ON SIDES AND BOTTOM WITH EPOXY SEALER LIQUID TIGHT.
8. PROVIDE 3" PVC COATED RIGID GALVANIZED STEEL CONDUIT WITH PULL WIRE FOR INSTALLATION OF CONDUCTORS BY OTHERS. STUB UP INSIDE FENCE ENCLOSURE & AT SERVICE STATION & TERMINATE IN NEMA 3R JUNCTION BOX 12" ABOVE GRADE.



TRENCH SECTION 1

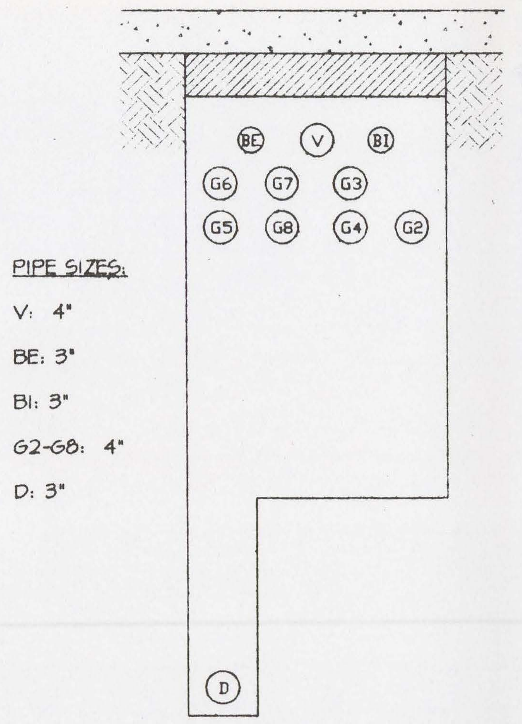
NO SCALE

NOTE:
DIMENSION INFORMATION IS TYPICAL FOR ALL SECTIONS EXCEPT FOR DEPTH.
SMALLER TRENCH WIDTHS AND DEPTHS MAY BE USED FOR RUNOUTS TO WELLS. TOP OF PIPE SHALL BE A MINIMUM OF 15" BELOW GRADE, CLEARANCE BETWEEN PIPE WALL AND TRENCH WALL SHALL BE A MINIMUM OF 3" AND BOTTOM OF PIPE TO TRENCH SHALL BE A MINIMUM OF 3". TRENCH COVER AND FILL DETAILS SHALL BE SIMILAR TO THOSE SHOWN.



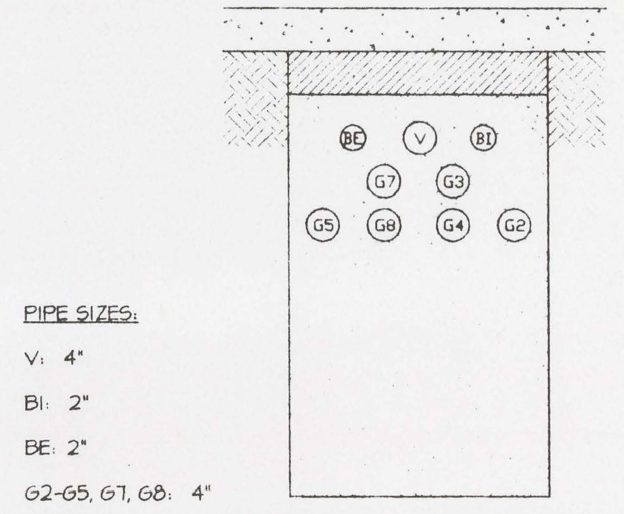
TRENCH SECTION 2

NO SCALE



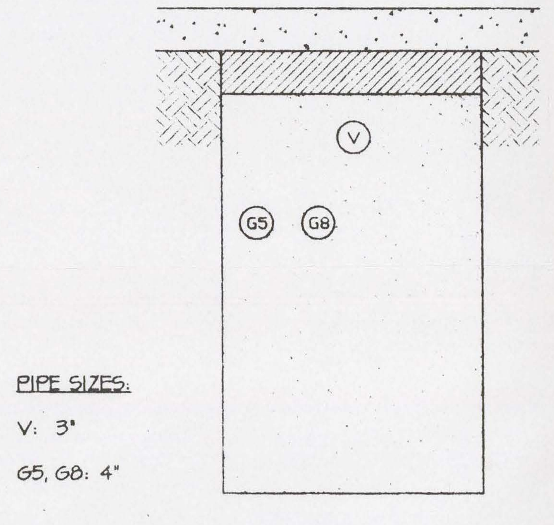
TRENCH SECTION 3

NO SCALE



TRENCH SECTION 4

NO SCALE

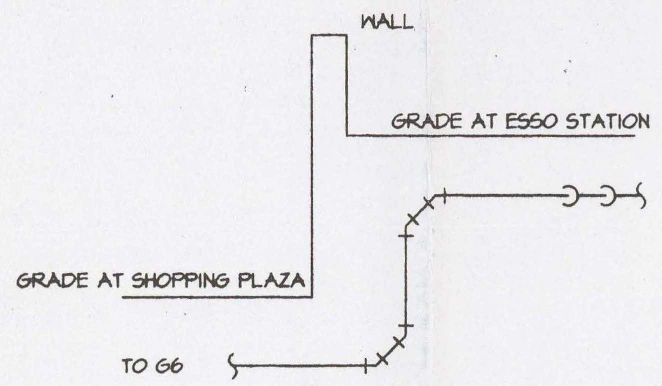


TRENCH SECTION 5

NO SCALE

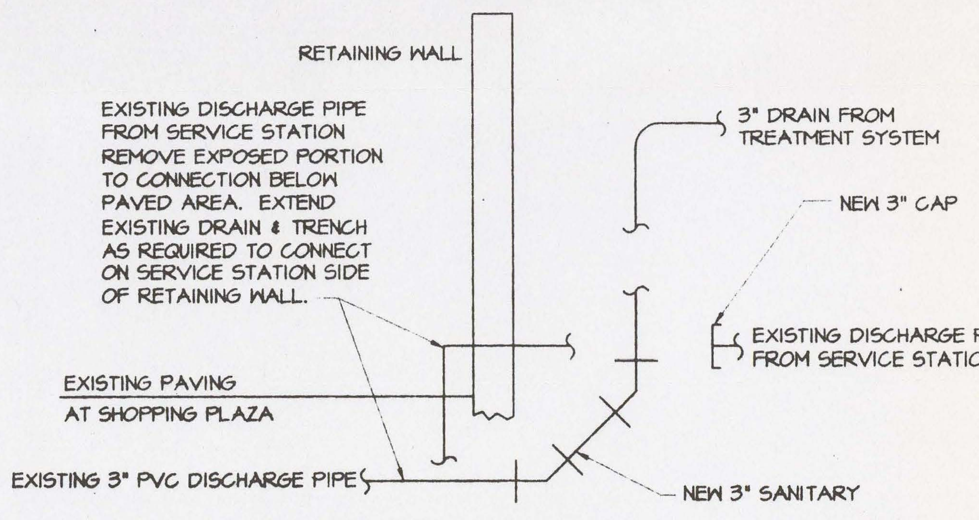
LEGEND:

- ■ VAPOR EXTRACTION WELL
- ● BIOVENT EXTRACTION WELL
- ⊕ BIOVENT INJECTION WELL
- ▲ GROUNDWATER EXTRACTION WELL
- GROUNDWATER EXTRACTION WELL TO BE USED LATER AS A BIOVENT INJECTION WELL
- V VAPOR EXTRACTION
- BE BIOVENT EXTRACTION
- BI BIOVENT INJECTION
- G8 GROUNDWATER LINE #
- G3/BI COMBINATION GROUNDWATER/ BIOVENT WELL
- D DRAIN
- □ PULL STATION
- SECTION



SECTION 6

NO SCALE



DRAIN CONNECTION SCHEMATIC CROSS SECTION

NO SCALE

LOCATION & DIMENSIONS ARE ACCURATELY SCALED FOR BIDDING & SCHEMATIC CONSTRUCTION PURPOSES. FINAL POSITION OF WELLS, PIPING & OTHER SYSTEM COMPONENTS MUST BE VERIFIED IN FIELD BEFORE BEGINNING CONSTRUCTION ACTIVITIES.

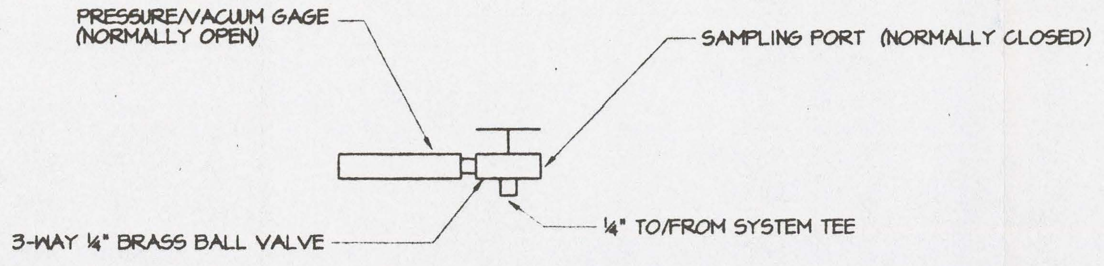
NO.	DATE	REVISIONS	DRN.	CHKD.

HBA
HILL & BELL ASSOCIATES, INC.
ENGINEERS / CONSULTANTS
131 MOUNT WELCOME - UNIT 6-8 - P.O. BOX 25867
CHRISTIANSTED, ST. CROIX, U.S.V.I. 00824-1867
PHONE (809) 773-0123 FAX (809) 773-0152

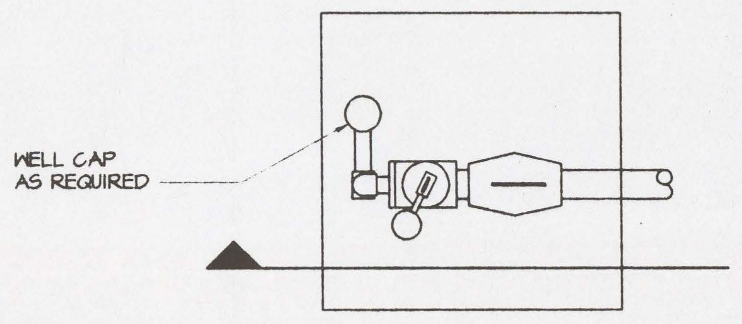
FORENSIC ENVIRONMENTAL SERVICES, INC.

ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
SITE PLAN, NOTES, AND DETAILS

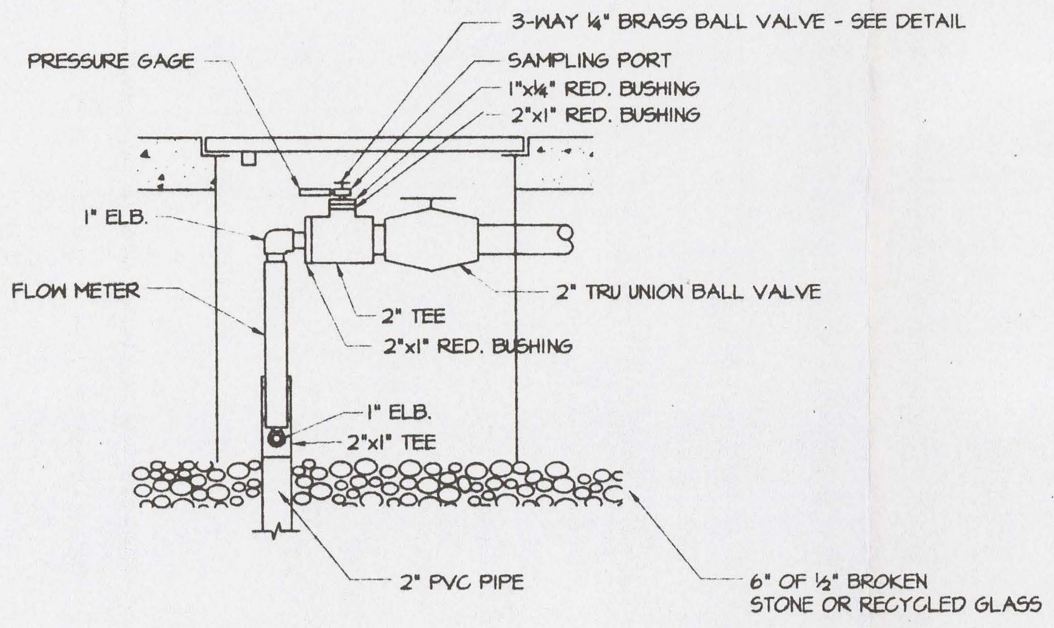
PROJ. NO.: 1675
DATE: 8/14/98
SCALE: AS NOTED
DRAWN: MLE
CHECKED: BHB
DRAWING NO. M-1



3-WAY VALVE DETAIL



PLAN

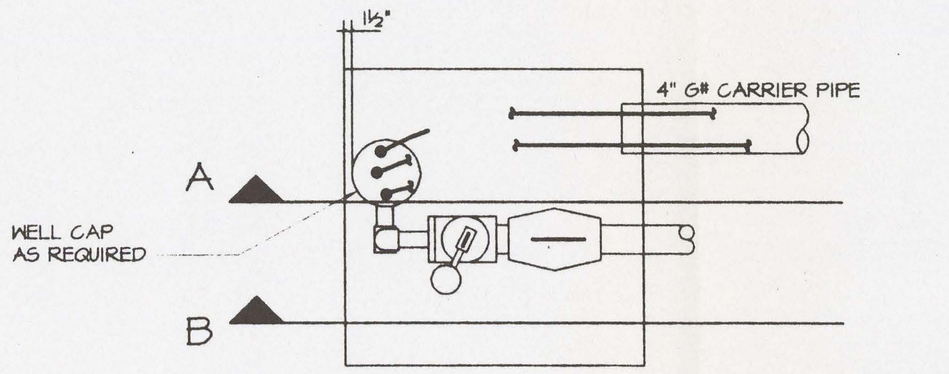


SECTION

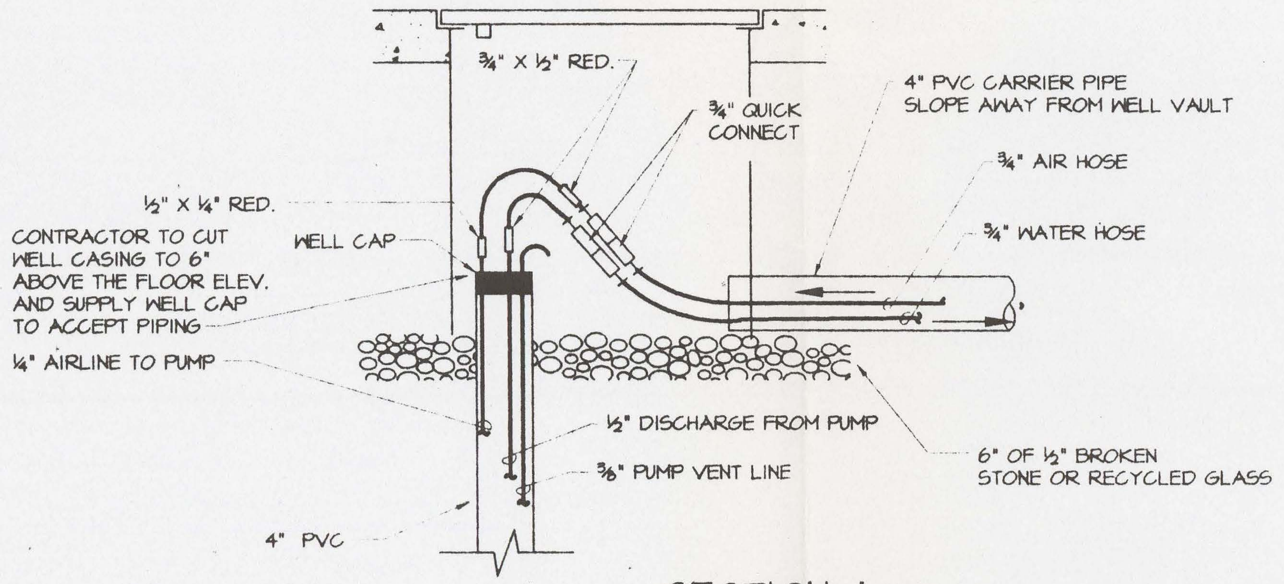
B1, BE & V WELL ENCLOSURE

NO SCALE

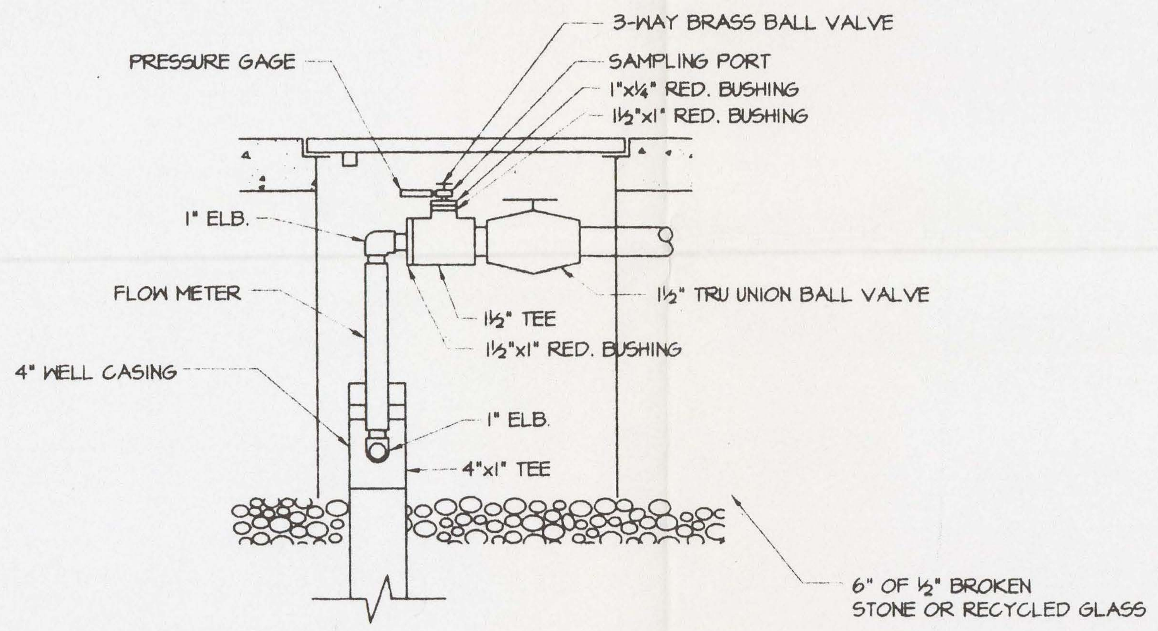
ARRANGEMENT SHOWN IS FOR V SYSTEM
WELL, VALVE, TEE, & BUSHINGS ARE 1½" FOR BE & B1 SYSTEM



PLAN



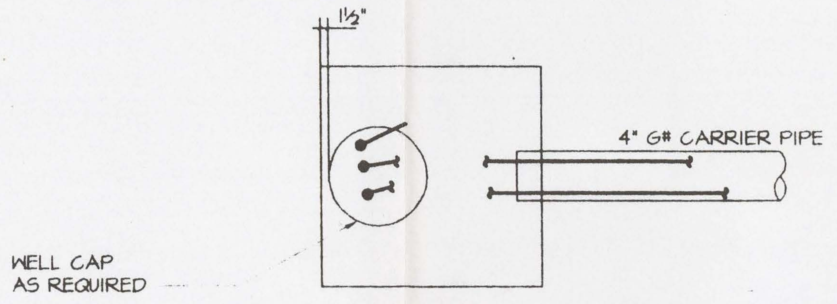
SECTION A



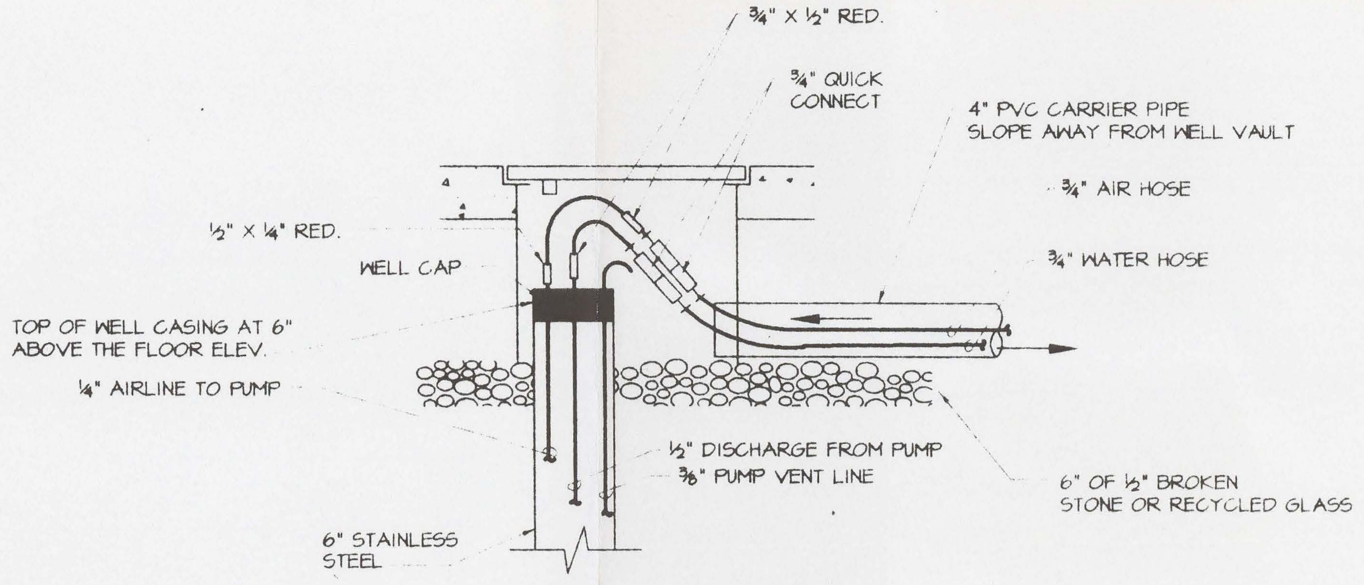
SECTION B

G1/B1, G2/B1, G3/B1, & G4/B1 GROUNDWATER WELL ENCLOSURE

NO SCALE



PLAN



SECTION

G5, G6, G7, & G8 GROUNDWATER WELL ENCLOSURE

NO SCALE

NOTES AND SPECIFICATIONS

VAULT ENCLOSURES: PEMCO MODEL 105242424WT
VAULTS WILL BE INSTALLED BY OTHERS.
CONTRACTOR SHALL FIELD CUT HOLES FOR PIPES AND SEAL WATERTIGHT WITH SILICONE SEALANT.

FLOW METERS: SUPPLIED BY OTHERS FOR INSTALLATION BY CONTRACTOR.

GAGES, SAMPLE PORTS, & WELL CAPS: SUPPLIED AND INSTALLED BY OTHERS

AIR & WATER HOSE: CONTRACTOR SHALL FURNISH AND INSTALL LINES FROM TERMINATION AT TRAILER UP TO & INCLUDING THE QUICK CONNECT AT THE WELL VAULT. FROM THE QUICK CONNECT TO THE WELL WILL BE SUPPLIED & INSTALLED BY OTHERS. PROVIDE 20' OF ADDITIONAL AT TREATMENT AREA TERMINATION.

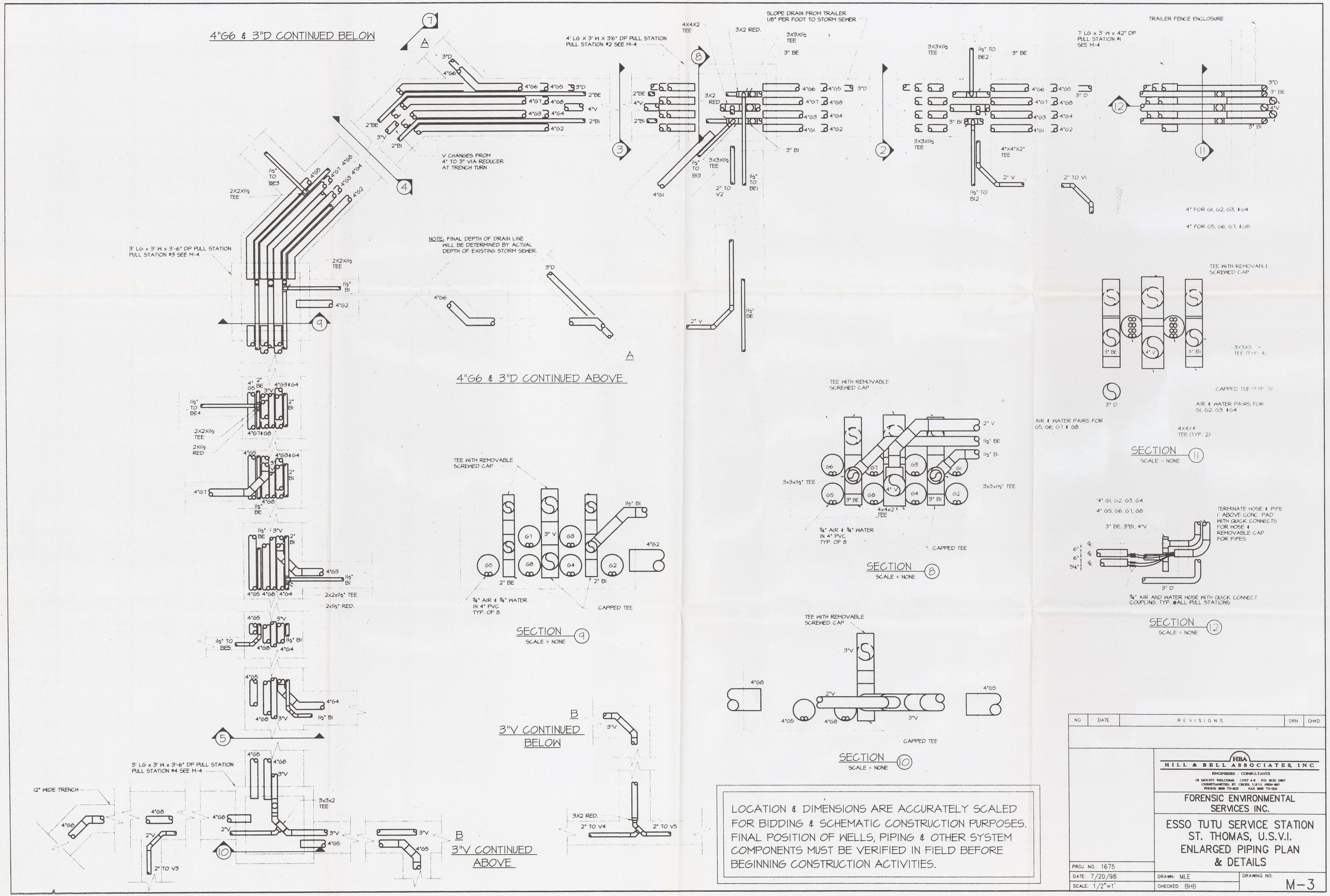
NO.	DATE	REVISIONS	DRN.	CHKD.

HBA
HILL & BELL ASSOCIATES, INC.
ENGINEERS / CONSULTANTS

FORENSIC ENVIRONMENTAL SERVICES, INC.

ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
WELL VAULT DETAILS

PROJ. NO.: 1675
DATE: 8/14/98
SCALE: NONE
DRAWN: MLE
CHECKED: BHB
DRAWING NO. M-2



LOCATION & DIMENSIONS ARE ACCURATELY SCALED FOR BIDDING & SCHEMATIC CONSTRUCTION PURPOSES. FINAL POSITION OF WELLS, PIPING & OTHER SYSTEM COMPONENTS MUST BE VERIFIED IN FIELD BEFORE BEGINNING CONSTRUCTION ACTIVITIES.

NO.	DATE	REVISIONS	DRN.	CHKD

HBA
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ENGINEERS / CONSULTANTS
131 MOUNT WELCOME - UNIT 6-6 - P.O. BOX 25867
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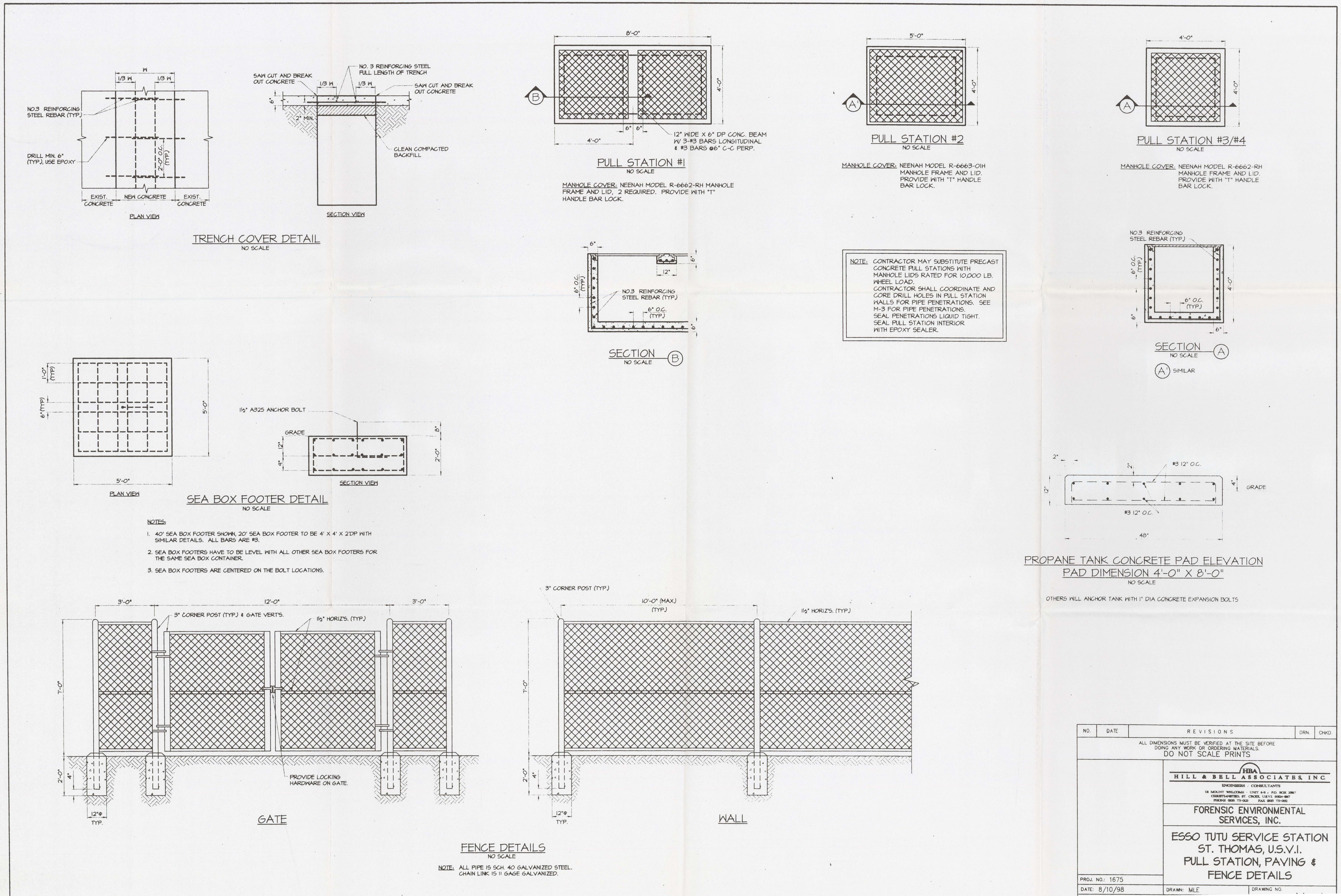
FORENSIC ENVIRONMENTAL SERVICES INC.

ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
ENLARGED PIPING PLAN
& DETAILS

PROJ. NO.: 1675
DATE: 7/20/98
SCALE: 1/2"=1'
DRAWN: MLE
CHECKED: BHB
DRAWING NO. M-3



TRENCH COVER DETAIL
NO SCALE
W
1/3 W
1/3 W
NO.3 REINFORCING STEEL REBAR (TYP.)
DRILL MIN. 6" (TYP.), USE EPOXY
2'-0" O.C. (TYP.)
EXIST. CONCRETE
NEW CONCRETE
EXIST. CONCRETE
PLAN VIEW
SAW CUT AND BREAK OUT CONCRETE
NO. 3 REINFORCING STEEL FULL LENGTH OF TRENCH
SAW CUT AND BREAK OUT CONCRETE
6"
2" MIN.
CLEAN COMPACTED BACKFILL
SECTION VIEW
PULL STATION #1
NO SCALE
8'-0"
4'-0"
6"
12" WIDE X 6" DP CONC. BEAM W/ 3-#3 BARS LONGITUDINAL & #3 BARS @6" C-C PERP.
MANHOLE COVER: NEENAH MODEL R-6662-RH MANHOLE FRAME AND LID, 2 REQUIRED. PROVIDE WITH "T" HANDLE BAR LOCK.
PULL STATION #2
NO SCALE
5'-0"
4'-0"
MANHOLE COVER: NEENAH MODEL R-6663-01H MANHOLE FRAME AND LID. PROVIDE WITH "T" HANDLE BAR LOCK.
PULL STATION #3/#4
NO SCALE
4'-0"
MANHOLE COVER: NEENAH MODEL R-6662-RH MANHOLE FRAME AND LID. PROVIDE WITH "T" HANDLE BAR LOCK.
SECTION B
NO SCALE
6"
12"
6" O.C. (TYP.)
NO.3 REINFORCING STEEL REBAR (TYP.)
NOTE: CONTRACTOR MAY SUBSTITUTE PRECAST CONCRETE PULL STATIONS WITH MANHOLE LIDS RATED FOR 10,000 LB. WHEEL LOAD. CONTRACTOR SHALL COORDINATE AND CORE DRILL HOLES IN PULL STATION WALLS FOR PIPE PENETRATIONS. SEE M-3 FOR PIPE PENETRATIONS. SEAL PENETRATIONS LIQUID TIGHT. SEAL PULL STATION INTERIOR WITH EPOXY SEALER.
SECTION A
NO SCALE
A' SIMILAR
NO.3 REINFORCING STEEL REBAR (TYP.)
6" O.C. (TYP.)
4'-0"
SEA BOX FOOTER DETAIL
NO SCALE
1'-0" (TYP.)
6" (TYP.)
5'-0"
PLAN VIEW
1½" A325 ANCHOR BOLT
GRADE
12"
4"
8"
2'-0"
SECTION VIEW
NOTES:
1. 40' SEA BOX FOOTER SHOWN, 20' SEA BOX FOOTER TO BE 4' X 4' X 2'DP WITH SIMILAR DETAILS. ALL BARS ARE #3.
2. SEA BOX FOOTERS HAVE TO BE LEVEL WITH ALL OTHER SEA BOX FOOTERS FOR THE SAME SEA BOX CONTAINER.
3. SEA BOX FOOTERS ARE CENTERED ON THE BOLT LOCATIONS.
PROPANE TANK CONCRETE PAD ELEVATION
PAD DIMENSION 4'-0" X 8'-0"
NO SCALE
2"
#3 12" O.C.
12"
4"
GRADE
48"
OTHERS WILL ANCHOR TANK WITH 1" DIA CONCRETE EXPANSION BOLTS
FENCE DETAILS
NO SCALE
3'-0"
12'-0"
3'-0"
3" CORNER POST (TYP.) & GATE VERT'S.
1½" HORIZ'S. (TYP.)
7'-0"
2'-0"
PROVIDE LOCKING HARDWARE ON GATE.
12"Φ TYP.
GATE
3" CORNER POST (TYP.)
10'-0" (MAX.) (TYP.)
1½" HORIZ'S. (TYP.)
WALL
NOTE: ALL PIPE IS SCH. 40 GALVANIZED STEEL. CHAIN LINK IS 11 GAGE GALVANIZED.
NO.
DATE
REVISIONS
DRN.
CHKD.
ALL DIMENSIONS MUST BE VERIFIED AT THE SITE BEFORE DOING ANY WORK OR ORDERING MATERIALS.
DO NOT SCALE PRINTS
HBA
HILL & BELL ASSOCIATES, INC.
ENGINEERS · CONSULTANTS
FORENSIC ENVIRONMENTAL SERVICES, INC.
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.
PULL STATION, PAVING & FENCE DETAILS
PROJ. NO.: 1675
DATE: 8/10/98
DRAWN: MLE
DRAWING NO.

APPENDIX B
Treatment System Design Drawings and Specifications List

BILL OF MATERIALS
Forensic Environmental Services, Inc.
LFR Proj. No. 315-88006-00-000

Component	Tag Number	Qty.	P.O. #	Unit Cost	Ext. Cost	Date Purchased	Date Arrived	Notes
Groundwater Treatment System								
Air Compressor	COM-101	1						
Air Dryer	AD-101	1						
Filter	CF/PF-101	1						
Solenoid Valve	SV-101	1						
Ball Valves		30						
Flow Meters	FM-103 thru 110	8						
Oil/Water Separator	OWS-101	1						
Product Recovery Drum	PRD-101	1						
Equalization Tank	T-101	1						
Transfer Pump	P-101	1						
Bag Filters	BFH-101 thru 103	3						
Stripper Blower	B-101	1						
Air Stripper	LPAS-101	1						
Stripper Effluent Pump	P-102	1						
Liquid Phase Carbon System	GAC-101 and 102	2						
Differential Pressure Switches	DPS-101 thru 103	3						
Totalizing Flow Meter	TFM-101	1						
Pressure Indicators		6						
Pressure Regulators	PR-101 thru 109	9						
Level Switches		7						
Metering Pump	MP-101	1						
Mix Tank w/ Agitator	T-102	1						
Flow Switch	FS-101	1						
Well Pumps	WP-101 thru 108	8						
Air Injection System								
Bioventing Blower	B-102	1						
Air Filter	F-102	1						
Air Flow Meters	AFM-107 thru 111	5						
Pressure Relief Valve	PRV-103	1						
Ball Valves		5						
Air Extraction System								
Air Flow Meter	AFM-101	1						

BILL OF MATERIALS
Forensic Environmental Services, Inc.
LFR Proj. No. 315-88006-00-000

Component	Tag Number	Qty.	P.O. #	Unit Cost	Ext. Cost	Date Purchased	Date Arrived	Notes
Air Flow Meter	AFM-102 thru 106	5						
Air Flow Meter	AFM-112 thru 116	5						
Ball Valves		30						
Vacuum Indicators		10						
Moisture Seperator	KOD-101	1						
Positive Displacement Pump	PDP-101	1						
Vapor Extraction Blower	VP-101	1						
Inline Particulate Filter	F-101 and 103	2						
Differential Pressure Switch	DPS-104	1						
Vacuum Relief Valve	VRV-101	1						
Pressure Relief Valve	PRV-102	1						
Level Switches		3						

NEEP™ Systems
environmental technologies

North East Environmental Products, Inc.
17 Technology Drive West Lebanon, NH 03784
603-298-7061 Fax: 603-298-7063

RECEIVED
SEP 4 1998

Date: Friday, May 29, 1998

To: Paul Fisher / Lavine-Frike
Fax: 908 526-7886
Phone: 908 526-1000 x 416

CC:
Fax:
Phone:

From: Bob Clarke / NEEP
No Pages: 2 (including this cover page)
RE:
Notes:

The Modeling software operation is based on actual test data we performed on the ShallowTray strippers. Modeler uses equations and the curve fitted test data to predict removal efficiencies.

Enclosed is an article that states this. It was the only statement I could find.

Bob Clarke
Project Manager
Senior Mechanical Engineer

fax 59 Lavine

incorporated into computer models that can be used to select air stripping equipment according to the environmental engineer's performance criteria and variables such as the chemical to be removed, air flow rates, water flow rate, water temperature, and others.

The modeling of air stripping systems is extremely important to the environmental engineer for several reasons:

1. A precise understanding of how variously configured air stripping systems will perform under a wide variety of conditions makes it possible for the manufacturer to assume liability for the performance of properly installed systems. This relieves the consulting engineer of the burden of performing his or her own performance testing.
2. The computer model makes it possible to perform hours worth of manual calculations in a matter of minutes. As a result, a manufacturer can respond quickly to a request for quotes or changes in performance criteria. Such responsiveness cannot be overemphasized. While site owners are given years to perform initial assessments and feasibility studies, they are typically given only 90 days to complete the final design and engineering of a treatment system. This causes enormous time pressures.
3. Modeling makes it possible to quickly troubleshoot performance issues with installed systems. These are frequently due to changes in site conditions (e.g., flow rates or contaminant concentrations). Based on the modeled data, it is possible to recommend modifications to system operation or configuration to improve performance.

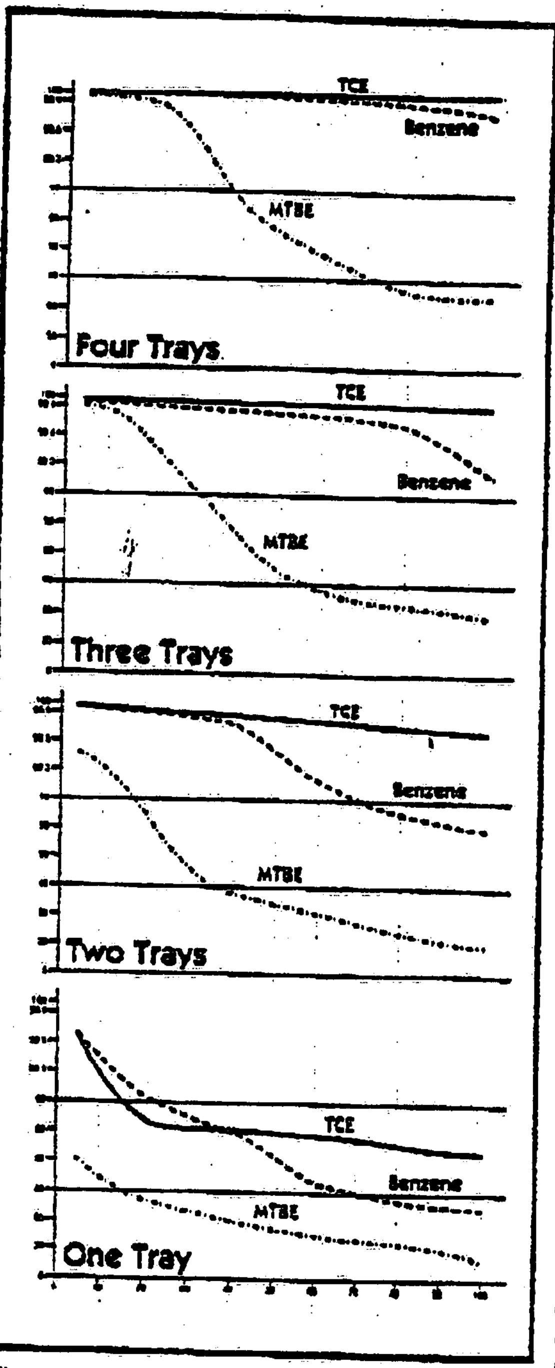


Figure 3

The degree of confidence one can have in modeled data for air stripper selection is limited by the manufacturer's experience with the compound matrix (i.e., the water itself, the primary contaminant(s), and other chemicals and minerals that may be present.) Computer models for selecting air strippers can be based on theoretical equations or on empirical data. However, the best models rely on theoretical equations calibrated to actual test data. This gives the engineer maximum assurance that predicted performance will closely approximate performance in the field. Some manufacturers perform many such tests every week, just to extend the data available on their systems and to keep pace with continually more demanding performance criteria. The value of the air stripper depends to a great extent on the scope and precision of its modeling.

Treatment Efficiencies

The higher the concentration of contamination in the water, the more air will be needed to volatilize and carry it away. To improve the treatment efficiency, it is therefore necessary to increase the air-water ratio. Tray-type, low-profile strippers have inherently high air-water ratios because relatively large volumes of air are required to transform water in the tray into a froth. Without oversizing the blowers, such units are capable of removing such highly soluble contaminants as methyl(tert)butyl ether (MTBE), methylene chloride, and acetone.

If additional treatment efficiency is required, it is possible to further increase the air-water ratio by reducing the flow rate of water through the system. Tray-type units may be operated anywhere within their rated water flow range. A small system may have a flow rating of 1 to 15 gallons per minute (gpm), while a large unit may have a range of 16 to 360 gpm. Either system may be operated at the lower limit to obtain a high contaminant removal efficiency. Residence time in a tower may also be a factor for improving treatment efficiency, but this generally involves increasing the height of the tower. Packed towers should not be operated at low flow rates because adequate mass transfer surface area cannot be generated.

Residence time in tray-type systems can be improved by adding more trays. In a multi-tray system, when water has reached the end of one tray, it falls into the next for additional treatment. Adding trays also makes it possible to operate at higher water flow rates without sacrificing air stripping efficiency. Figure 3 shows removal efficiency vs. flow rates for systems with one, two, three, and four trays, respectively. The ability to easily remove or add trays in the field makes it possible to periodically tune the system for improved performance or reduced operating costs.

ShallowTray

low profile air strippers

DRAFT

System Performance Estimate

Client and Proposal Information:

Forensic Environmental

Model Chosen: 2300
Water Flow Rate: 10.0 gpm
Air Flow Rate: 300 cfm
Water Temp: 60.0 F
Air Temp: 60.0 F
A/W Ratio: 224.4
Safety Factor: None

Contaminant	Untreated Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
Benzene	**2250 ppb** 15 ppb	**30 ppb** 0.011105 98.6701%	**1 ppb** 0.011250 99.9823%	**<1 ppb** 0.011255 99.9998%	**<1 ppb** 0.011255 100.0000%
MTBE	**20000 ppb** 1000 ppb	**4364 ppb** 0.078214 78.1819%	**953 ppb** 0.095277 95.2397%	**208 ppb** 0.099004 98.9614%	**46 ppb** 0.099814 99.7734%
p-Xylene	**1900 ppb** 50 ppb	**25 ppb** 0.009379 98.7294%	**1 ppb** 0.009499 99.9839%	**<1 ppb** 0.009504 99.9998%	**<1 ppb** 0.009504 100.0000%
Toluene	**150 ppb** 50 ppb	**3 ppb** 0.000735 98.3680%	**<1 ppb** 0.000750 99.9734%	**<1 ppb** 0.000750 99.9996%	**<1 ppb** 0.000750 100.0000%
Ethyl Benzene	**700 ppb** 50 ppb	**8 ppb** 0.003462 98.8798%	**<1 ppb** 0.003501 99.9874%	**<1 ppb** 0.003502 99.9999%	**<1 ppb** 0.003502 100.0000%
Trichloroethylene	**5 ppb** 1 ppb	**<1 ppb** 0.000025 99.7067%	**<1 ppb** 0.000025 99.9991%	**<1 ppb** 0.000025 100.0000%	**<1 ppb** 0.000025 100.0000%
Tetrachloroethylene	**15 ppb** 1 ppb	**<1 ppb** 0.000075 99.8327%	**<1 ppb** 0.000075 99.9997%	**<1 ppb** 0.000075 100.0000%	**<1 ppb** 0.000075 100.0000%
1,1-Dichloroethylene	**25 ppb** 1 ppb	**<1 ppb** 0.000124 99.4946%	**<1 ppb** 0.000125 99.9974%	**<1 ppb** 0.000125 100.0000%	**<1 ppb** 0.000125 100.0000%
Vinyl Chloride	**5 ppb** 1 ppb	**<1 ppb** 0.000025 99.9822%	**<1 ppb** 0.000025 100.0000%	**<1 ppb** 0.000025 100.0000%	**<1 ppb** 0.000025 100.0000%

Page 2

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Contaminant	Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
Acetone	5 ppb 1 ppb	4 ppb 0.000005 20.8477%	4 ppb 0.000005 37.3491%	3 ppb 0.000010 50.4104%	2 ppb 0.000015 60.7487%

Due to its miscibility with water, acetone removal is difficult to predict. Call your neep representative for more in

Contaminant	Influent Effluent Target	Model 2311	Model 2321	Model 2331	Model 2341
Methylene Chloride	15 ppb 1 ppb	1 ppb 0.000070 98.0893%	<1 ppb 0.000075 99.9635%	<1 ppb 0.000075 99.9993%	<1 ppb 0.000075 100.0000%

This report has been generated by ShallowTray Modeler software version 2.1W. This software is designed to assist a skilled operator in predicting the performance of a ShallowTray air stripping system. North East Environmental Products, Inc. is not responsible for incidental or consequential damages resulting from the improper operation of either the software or the air stripping equipment.
Report generated: 9/16/1998

ShallowTray
low profile air strippers

DRAFT

System Performance Estimate

Client and Proposal Information:

Forensic Environmental

Model Chosen:	2300
Water Flow Rate:	12.0 gpm
Air Flow Rate:	300 cfm
Water Temp:	60.0 F
Air Temp:	60.0 F
A/W Ratio:	187.0
Safety Factor:	None

Contaminant	Untreated Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
Benzene	**2250 ppb** 15 ppb	**50 ppb** 0.013206 97.7943%	**2 ppb** 0.013494 99.9513%	**<1 ppb** 0.013506 99.9989%	**<1 ppb** 0.013506 100.0000%
MTBE	**20000 ppb** 1000 ppb	**5607 ppb** 0.086396 71.9692%	**1572 ppb** 0.110617 92.1428%	**441 ppb** 0.117406 97.7976%	**124 ppb** 0.119309 99.3826%
p-Xylene	**1900 ppb** 50 ppb	**41 ppb** 0.011159 97.8813%	**1 ppb** 0.011399 99.9551%	**<1 ppb** 0.011405 99.9990%	**<1 ppb** 0.011405 100.0000%
Toluene	**150 ppb** 50 ppb	**4 ppb** 0.000876 97.3574%	**<1 ppb** 0.000900 99.9302%	**<1 ppb** 0.000900 99.9982%	**<1 ppb** 0.000900 100.0000%
Ethyl Benzene	**700 ppb** 50 ppb	**14 ppb** 0.004118 98.1044%	**1 ppb** 0.004196 99.9641%	**<1 ppb** 0.004202 99.9993%	**<1 ppb** 0.004202 100.0000%
Trichloroethylene	**5 ppb** 1 ppb	**<1 ppb** 0.000030 99.5170%	**<1 ppb** 0.000030 99.9977%	**<1 ppb** 0.000030 100.0000%	**<1 ppb** 0.000030 100.0000%
Tetrachloroethylene	**15 ppb** 1 ppb	**<1 ppb** 0.000090 99.7110%	**<1 ppb** 0.000090 99.9992%	**<1 ppb** 0.000090 100.0000%	**<1 ppb** 0.000090 100.0000%
1,1-Dichloroethylene	**25 ppb** 1 ppb	**<1 ppb** 0.000149 99.3448%	**<1 ppb** 0.000150 99.9857%	**<1 ppb** 0.000150 100.0000%	**<1 ppb** 0.000150 100.0000%
Vinyl Chloride	**5 ppb** 1 ppb	**<1 ppb** 0.000030 99.9627%	**<1 ppb** 0.000030 100.0000%	**<1 ppb** 0.000030 100.0000%	**<1 ppb** 0.000030 100.0000%

Page 2

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Contaminant	Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
Acetone	**5 ppb** 1 ppb	**5 ppb** <.000001 16.6703%	**4 ppb** 0.000006 30.5616%	**3 ppb** 0.000012 42.1372%	**3 ppb** 0.000012 51.7631%

Due to its miscibility with water, acetone removal is difficult to predict. Call your neep representative for more in

Contaminant	Influent Effluent Target	Model 2311	Model 2321	Model 2331	Model 2341
Methylene Chloride	**15 ppb** 1 ppb	**1 ppb** 0.000084 96.6073%	**<1 ppb** 0.000090 99.8849%	**<1 ppb** 0.000090 99.9961%	**<1 ppb** 0.000090 99.9999%

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Report generated: 9/16/1998

ShallowTray
low profile air strippers

DRAFT

System Performance Estimate

Client and Proposal Information:

Forensic Environmental

Model Chosen:	2300
Water Flow Rate:	15.0 gpm
Air Flow Rate:	300 cfm
Water Temp:	60.0 F
Air Temp:	60.0 F
A/W Ratio:	149.6
Safety Factor:	None

Contaminant	Untreated Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
Benzene	2250 ppb 15 ppb	93 ppb 0.016185 95.8802%	4 ppb 0.016852 99.8303%	<1 ppb 0.016881 99.9930%	<1 ppb 0.016882 99.9997%
MTBE	20000 ppb 1000 ppb	7441 ppb 0.094234 62.7985%	2768 ppb 0.129297 86.1605%	1030 ppb 0.142338 94.8515%	384 ppb 0.147185 98.0847%
p-Xylene	1900 ppb 50 ppb	76 ppb 0.013686 96.0165%	4 ppb 0.014226 99.8413%	<1 ppb 0.014255 99.9937%	<1 ppb 0.014256 99.9997%
Toluene	150 ppb 50 ppb	8 ppb 0.001065 95.2081%	1 ppb 0.001118 99.7704%	<1 ppb 0.001125 99.9890%	<1 ppb 0.001125 99.9995%
Ethyl Benzene	700 ppb 50 ppb	26 ppb 0.005057 96.3704%	1 ppb 0.005245 99.8683%	<1 ppb 0.005252 99.9952%	<1 ppb 0.005252 99.9998%
Trichloroethylene	5 ppb 1 ppb	<1 ppb 0.000037 99.0458%	<1 ppb 0.000038 99.9909%	<1 ppb 0.000038 99.9999%	<1 ppb 0.000038 100.0000%
Tetrachloroethylene	15 ppb 1 ppb	<1 ppb 0.000112 99.3903%	<1 ppb 0.000113 99.9963%	<1 ppb 0.000113 100.0000%	<1 ppb 0.000113 100.0000%
1,1-Dichloroethylene	25 ppb 1 ppb	<1 ppb 0.000186 99.0827%	<1 ppb 0.000188 99.9916%	<1 ppb 0.000188 99.9999%	<1 ppb 0.000188 100.0000%
Vinyl Chloride	5 ppb 1 ppb	<1 ppb 0.000037 99.8978%	<1 ppb 0.000038 99.9999%	<1 ppb 0.000038 100.0000%	<1 ppb 0.000038 100.0000%

Page 2

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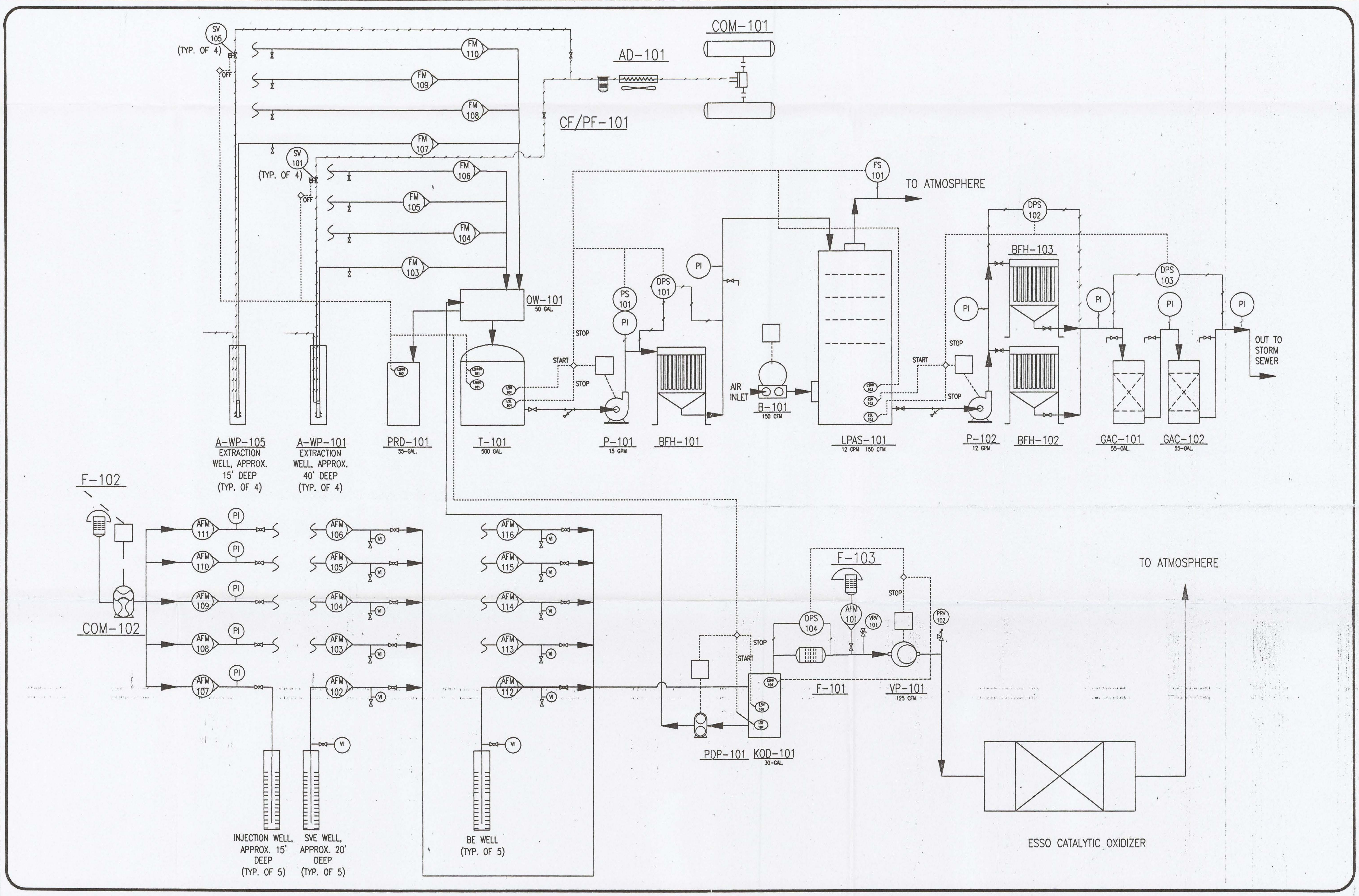
Contaminant	Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
Acetone	5 ppb 1 ppb	5 ppb <.000001 12.8636%	4 ppb 0.000008 24.0725%	4 ppb 0.000008 33.8395%	3 ppb 0.000015 42.3502%
Due to its miscibility with water, acetone removal is difficult to predict. Call your neep representative for more in					
Methylene Chloride	15 ppb 1 ppb	2 ppb 0.000098 92.7069%	<1 ppb 0.000112 99.4681%	<1 ppb 0.000113 99.9612%	<1 ppb 0.000113 99.9972%

This report has been generated by ShallowTray Modeler software version 2.1W. This software is designed to assist a skilled operator in predicting the performance of a ShallowTray air stripping system. North East Environmental Products, Inc. is not responsible for incidental or consequential damages resulting from the improper operation of either the software or the air stripping equipment.
Report generated: 9/16/1998



REV. STATUS	REVISION HISTORY			
REV.	SHT.			
ZONE	REV	DESCRIPTION	DATE	APPROVED
	1	GENERAL EDITS	9/98	PRF

IEC
INDEPENDENT EQUIPMENT CORPORATION
5 JOHNSON DRIVE, P.O. BOX 130
RARITAN, NEW JERSEY 08869-0130
(908) 526-1001/FAX (908) 526-7886

TITLE: PROCESS & INSTRUMENTATION DIAGRAM
SOIL VAPOR EXTRACTION &
GROUNDWATER TREATMENT SYSTEM

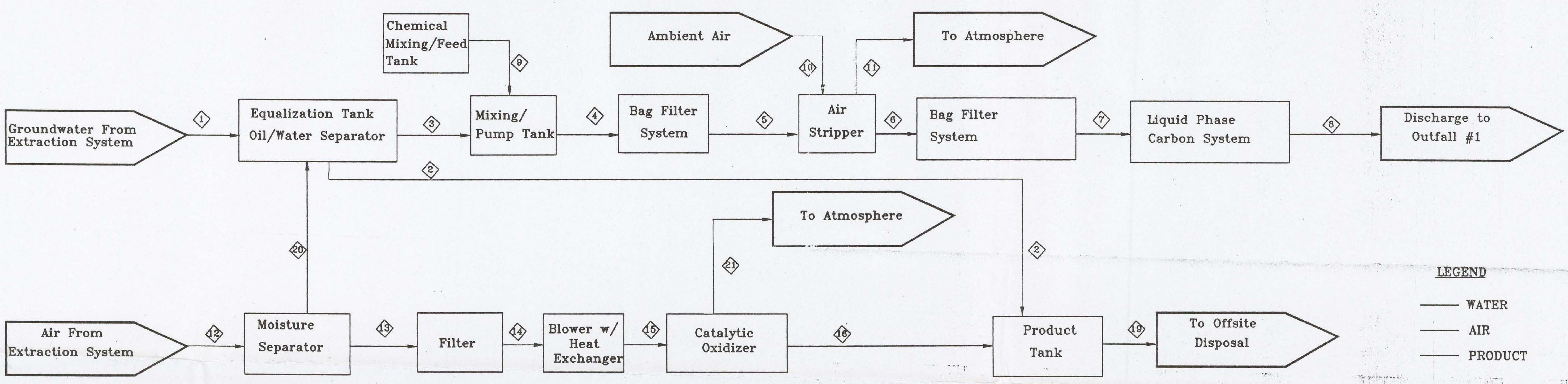
DATE:	05.28.97
DRAWN BY:	AKA
CHECKED BY:	PRF
APPROVED BY:	PRF
JOB NO.:	88006
CUSTOMER REF. NO.:	
CUSTOMER APPROVAL:	
CONTRACT NO.:	

CLIENT/LOCATION:

FORENSIC ENVIRONMENTAL SERVICES, INC.
623 NORTH POTTSTOWN PIKE, SUITE A
EXTON, PA 19341

SIZE	REVISION:	CAGE CODE:
C	1	

DWG. No.:	SHEET:	SCALE:
88006-00-601	I-1	N.T.S.



REV. STATUS		REVISION HISTORY			
REV.	SHT.				
ZONE	REV.	DESCRIPTION	DATE	APPROVED	
	1	GENERAL EDITS	9/98	PRF	

SIZE: C | REVISION: 1 | CAGE CODE:

IEC
INDEPENDENT EQUIPMENT CORPORATION
5 JOHNSON DRIVE, P.O. BOX 130
RARITAN, NEW JERSEY 08869-0130
(908) 526-1001/FAX (908) 526-7886

DWG. No.: 88006-00-006 | SHEET: I-2 | SCALE: N.T.S

TITLE: PROCESS FLOW DIAGRAM
SOIL VAPOR EXTRACTION &
GROUNDWATER TREATMENT SYSTEM

CLIENT/LOCATION:
FORENSIC ENVIRONMENTAL SERVICES, INC.
623 NORTH POTTSTOWN PIKE, SUITE A
EXTON, PA 19341

DATE:	05.28.97
DRAWN BY:	MAM
CHECKED BY:	RJT
APPROVED BY:	PRF
JOB NO.:	88006
CUSTOMER REF. NO.:	
CUSTOMER APPROVAL:	
CONTRACT NO.:	

APPENDIX C
Initial Testing Program

INITIAL TESTING PROGRAM

Esso Tutu Service Station
St. Thomas, U.S.V.I.

September 22, 1998

Prepared by:

Forensic Environmental Services, Inc.
113 John Robert Thomas Drive
The Commons at Lincoln Center
Exton, Pennsylvania, 19341

INITIAL TESTING PROGRAM

Per Section VIII, E1. of the UAO, an Initial Testing Program (ITP) has been developed for start-up and initial testing of the SVE (Remedial Element I) and Ground-Water Extraction/Treatment (Remedial Element II) systems. The purpose of the ITP is to ensure that the SVE and Ground-Water remedial systems operate and function as designed and constructed. The ITP establishes the empirical basis to finalize and implement long-term operation and maintenance of Esso's Source Control Plan.

The ITP will be implemented within 10 days of completing construction of the SVE and Ground Water remedial systems, and monitoring activities will extend over a period of 4 months. A pre-final inspection attended by EPA and/or their representative will also be performed during the performance of the ITP and a punch list of deficiencies developed, if any. Within 60 days of completing the monitoring associated with the ITP, the Remedial Construction Report will be submitted which presents the findings of the ITP, as well as the following: 1) empirical performance data; 2) a description of the construction work performed; 3) documentation of any changes from the approved design; and 4) "As-built" drawings.

The sampling activities planned to be conducted under the ITP are discussed in the following sections.

C.1 SVE (Remedial Element I)

SVE monitoring activities under the ITP will include field measurements obtained with a portable PID and CO/O_2 meters, as well as quantitative sampling of influent and effluent vapor samples for laboratory analysis. Table C-1 provides a comprehensive summary of the sampling and analyses that will be conducted in association with monitoring Remedial Element I during the first 4 months of operation. Principal aspects of the ITP monitoring program fro Remedial Element I have been summarized below.

- Weeks 0-2

  -Off-gas will be monitored with a field CO/O_2 meter four times /week. Vapor influent and effluent will be monitored using a PID four times/week and samples will be submitted twice per week for laboratory analysis for VOCs by Method TO-14.

  - Individual SVE wells will be monitored with a field CO_2/O_2 meter, PID, and for vacuum and flow rate four times /week. The induced vacuum at individual vapor monitoring points will be measured using a field gauge at the same frequency as the SVE wells.

- Weeks 2-8

  - Off-gas will be monitored with a field CO/O_2 meter twice/week. Vapor influent and effluent will be monitored using a PID twice/week and samples will be submitted twice/month for laboratory analysis for VOCs by Method TO-14.

  - Individual SVE wells will be monitored with a CO_2/O_2 meter, PID, and for vacuum and flow rate twice per week. Vapor samples from individual wells will be submitted monthly for laboratory analysis for VOCs by Method TO-14. The induced vacuum at individual vapor monitoring points will be measured twice/week using a field gauge.

- Months 2-4

  - Off-gas will be monitored with a field CO_2/O_2 meter weekly. Vapor influent and effluent will be monitored using a PID weekly and samples will be submitted monthly for laboratory analysis for VOCs by Method TO-14.

  - Individual SVE wells will be monitored with a CO_2/O_2 meter, PID, and for vacuum and flow rate monthly. Vapor samples from individual wells will be submitted periodically for laboratory analysis for VOCs by Method TO-14. The induced vacuum at individual vapor monitoring points will be measured monthly using a field gauge.

C.2 Ground-Water Extraction/Treatment (Remedial Element II)

Monitoring activities associated with the ground-water extraction/treatment system will include field measurements of temperature, pH, conductivity, DO and Redox Potential, quantitative sampling of ground-water samples for laboratory analysis, and liquid level measurements. Table C-2 provides a comprehensive summary of the sampling and analyses that will be conducted in association with Remedial Element II during the first 4 months of operation. Principal aspects of the ITP monitoring program for Remedial Element II have been summarized below.

- Weeks 0-2

  - Continuous water level measurements will be recorded in wells MW-8 and DW-1; daily liquid level measurements will be obtained in all on-site wells CHT-2, CHT-3, CHT-4, CHT-7D, MW-9S, MW-10, MW-10D, G6, and G-8.

  - Total gallons extracted from the eight recovery wells will be recorded daily.

  - Ground-water influent and effluent samples will be submitted weekly for laboratory analysis for BTEX by Method 8240, TPH by Method 8015A, and lead by Method 7421.

  - Ground-water influent samples will be submitted monthly for laboratory analysis for VOCs (Method 8240 and 8270).

  - Ground-water effluent will be submitted weekly for laboratory analysis for TOC by Method 9060A and TSS by Method 160.2. pH measurements will also be collected of ground-water effluent on a weekly basis and the discharge flow rate monitored on a weekly basis.

- Weeks 2-8

  - Continuous water level measurements will be recorded in wells MW-8 and DW-1; weekly liquid level measurements will be obtained in all on-site wells CHT-2, CHT-3, CHT-4, CHT-7D, MW-9S, MW-10, MW-10D, G6, and G-8.

  - Total gallons extracted from the eight recovery wells will be recorded weekly. Hardness and iron will monitored during one sampling event

  - Ground-water samples from the recovery wells will be submitted monthly for laboratory analysis for VOCs by Method 8240 and TPH by Method 8015A. Dissolved Oxygen levels and Redox Potential will be monitored with a field meter monthly.

  - Ground-water samples from wells SW-1, SW-3, SW-8, SW-9, and SW-10 will be submitted monthly for analysis for VOCs by Method 8240 and TPH by Method 8015A.

- Ground-water influent and effluent samples will be submitted weekly for laboratory analysis for BTEX by Method 8240, TPH by Method 8015A, and lead by Method 7421.

- Ground-water influent samples will be submitted monthly for laboratory analysis for VOCs (Method 8240 and 8270).

- Ground-water effluent will be submitted weekly for laboratory analysis for TOC by Method 9060A and TSS by Method 160.2. pH measurements will also be collected of ground-water effluent on a weekly basis and the discharge flow rate monitored on a weekly basis.

- Months 2-4

- Continuous water level measurements will be recorded in wells MW-8 and DW-1; weekly liquid level measurements will be obtained in all on-site wells CHT-2, CHT-3, CHT-4, CHT-7D, MW-9S, MW-10, MW-10D, G6, and G-8.

- Total gallons extracted from the eight recovery wells will be recorded monthly. Hardness and iron will monitored periodically

- Ground-water samples from the recovery wells will be submitted monthly for laboratory analysis for VOCs by Method 8240 and TPH by Method 8015A. Dissolved Oxygen levels and Redox Potential will be monitored with a field meter monthly.

- Ground-water samples from wells SW-1, SW-3, SW-8, SW-9, and SW-10 will be submitted monthly for analysis for VOCs by Method 8240 and TPH by Method 8015A.

- Ground-water influent and effluent samples will be submitted monthly for laboratory analysis for BTEX by Method 8240, TPH by Method 8015A, and lead by Method 7421.

- Ground-water influent samples will be submitted monthly for laboratory analysis for VOCs (Method 8240 and 8270).

- Ground-water effluent will be submitted weekly for laboratory analysis for TOC by Method 9060A and TSS by Method 160.2. pH measurements will also be collected of ground-water effluent on a weekly basis and the discharge flow rate monitored on a weekly basis.

C.3 Sampling Methods

Sampling activities will generally include: 1) the collection of vapor samples from extraction wells and the treatment system; and 2) ground-water samples from recovery wells, monitoring wells, and influent and effluent associated with the air stripper. To the extent applicable, sampling protocols will be in accordance with the US EPA approved Supplemental Remedial Design Work Plan (SRDWP) (FES, 1998) and the Quality Assurance Project Plan (QAPP) for the Tutu Service Station Investigation (Geraghty & Miller, 1992).

C.3.1 Vapor Monitoring/Sampling

Influent and effluent samples associated with the Cat-Ox system will be collected directly from sampling ports into the Tedlar bags for laboratory analyses and field measurements. Figure C-1 illustrates the sampling locations for the influent and effluent vapor samples associated with the Cat-Ox system. Additionally, discharge velocity, flow rate, and temperature readings will be recorded from gauges inside the treatment building. The induced vacuum at vapor monitoring points will be measured by placing a well cap fitted with a vacuum gauge and rubber gasket over the top of each vapor monitoring well.

Vapor samples will also be collected from individual SVE wells for laboratory analysis for VOCs and field measurements using PID and CO_2/O_2 meters. Samples will be collected from the sampling ports directly into the Tedlar bags. Field measurements using a PID and CO_2/O_2 meters will be obtained by connecting the meter probe to each sampling port with tygon tubing. Vacuum and flow rate readings will be recorded from field gauges installed at each well. Barometric and temperature measurements will be obtained from the monitoring station at the Cyril E. King Airport, St. Thomas.

C.3.2 Ground -Water Sampling

Influent and effluent samples associated with the ground-water treatment system will be collected directly from sampling ports into laboratory supplied sample containers with the proper preservatives as specified on Table C-3. Figure C-2 illustrates the collection points for the influent and effluent water samples. Additional ground-water samples will be collected from the following well locations :

- eight recovery wells (G1 through G8) at the Esso Tutu Service Station; and
- downgradient monitoring wells SW-1, SW-3, SW-5, SW-9, and SW-10.

Ground-water samples from the recovery wells will be collected directly from dedicated water lines located within the treatment building. These wells will be pumping on a continual basis and therefore will not need to be purged prior to sample collection.

A minimum of three well volumes will be removed from the downgradient monitoring wells prior to sampling. Submersible pumps will be decontaminated between each use. Field parameters including pH, specific conductance, and temperature will be measured and recorded for all ground-water samples at the time of collection. All measurement probes will be rinsed with distilled water between samples. The meters will be field calibrated daily according to the manufacturers recommendations.

Field QC samples will include travel blanks, equipment rinsate blanks, duplicates (blind), and matrix spike/matrix spike duplicate (MS/MSD) samples. Travel blanks will be submitted at a rate of one per cooler for samples being submitted for TCL VOC analysis. Equipment rinsate blanks will be collected for each sampling device associated with the ground-water samples. Blind duplicates and MS/MSD samples will be collected at the rate of 1 in 20 field samples and analyzed for the identical parameters as the associated environmental sample.

Well purging, sampling, decontamination, and waste handling procedures will be the same as those identified in the Supplemental Remedial Design Work Plan (FES, 1998).

All samples will be placed into a cooler with sufficient ice or ice packs to ensure the proper temperature (i.e., 4° C) is maintained. Chain-of-custody forms will accompany the samples inside the cooler for shipment to the laboratory. All coolers will be shipped by overnight courier to Lancaster Laboratories Inc. (LLI), an EPA CLP lab. Field notes documenting the sampling activities will be recorded in a bound field book.

Table C-3 summarizes the laboratory analytical methods for the various parameters, as well as the requirements for sample containers, preservation, and analysis holding times.

Table C-1
ITP Monitoring Summary - Remedial Work Element I
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Time From Initial System Operation	Project Phase	Treatment System Component	Sample Location	Sampling/Monitoring Parameter	Sampling Frequency
0-2 Weeks	Remedial Work Element I	Cat-Ox Air Pollution Control	Vapor Influent/Effluent	VOCs via TO-14	Twice per week
			Vapor Influent/Effluent	VOCs via field PID	Four times per week
			Vapor Effluent	CO/O_2 via field meter	Four times per week
			Vapor Effluent	discharge velocity via field meter	Four times per week
			Vapor Effluent	temperature, flow rate via cat-ox	Four times per week
		SVE	Individual SVE Wells	VOCs via PID	Four times per week
			Individual SVE Wells	CO_2/O_2 via field meter	Four times per week
			Individual SVE Wells	Vacuum, flow rate at well via field gauge	Four times per week
			Individual VMPs	Induced vacuum at well via field gauge	Four times per week
			Ambient Site Conditions	Barometric pressure, temperature via field meter	Four times per week
2- 8 Weeks	Remedial Work Element I	Cat-Ox Air Pollution Control	Vapor Influent/Effluent	VOCs via TO-14	Twice per month
			Vapor Influent/Effluent	VOCs via field PID	Twice per week
			Vapor Effluent	CO/O_2 via field meter	Twice per week
			Vapor Effluent	discharge velocity via field meter	Twice per week
			Vapor Effluent	temperature, flow rate via cat-ox	Twice per week
		SVE	Individual SVE Wells	VOCs via TO-14	Monthly
			Individual SVE Wells	VOCs via PID	Twice per week
			Individual SVE Wells	CO_2/O_2 via field meter	Twice per week
			Individual SVE Wells	Vacuum, flow rate at well via field gauge	Twice per week
			Individual VMPs	Induced vacuum at well via field gauge	Twice per week
			Ambient Site Conditions	Barometric pressure, temperature via field meter	Twice per week
2-4 months	Remedial Work Element I	Cat-Ox Air Pollution Control	Vapor Influent/Effluent	VOCs via TO-14	Monthly
			Vapor Influent/Effluent	VOCs via field PID	Weekly
			Vapor Effluent	CO/O_2 via field meter	Weekly
			Vapor Effluent	discharge velocity via field meter	Weekly
			Vapor Effluent	temperature, flow rate via cat-ox	Weekly
		SVE	Individual SVE Wells	VOCs via TO-14	Periodically
			Individual SVE Wells	VOCs via PID	Monthly
			Individual SVE Wells	CO_2/O_2 via field meter	Monthly
			Individual SVE Wells	Vacuum, flow rate at well via field gauge	Monthly
			Individual VMPs	Induced vacuum at well via field gauge	Monthly
			Ambient Site Conditions	Barometric pressure, temperature via field meter	Monthly

VMPs = vapor monitoring points, VOCs = volatile organic compounds, PID = photoionization detector

Table C-2
EFP Monitoring Summary - Remedial Work Element II
Esso Tutu Service Station
St. Thomas, U.S.V.I.

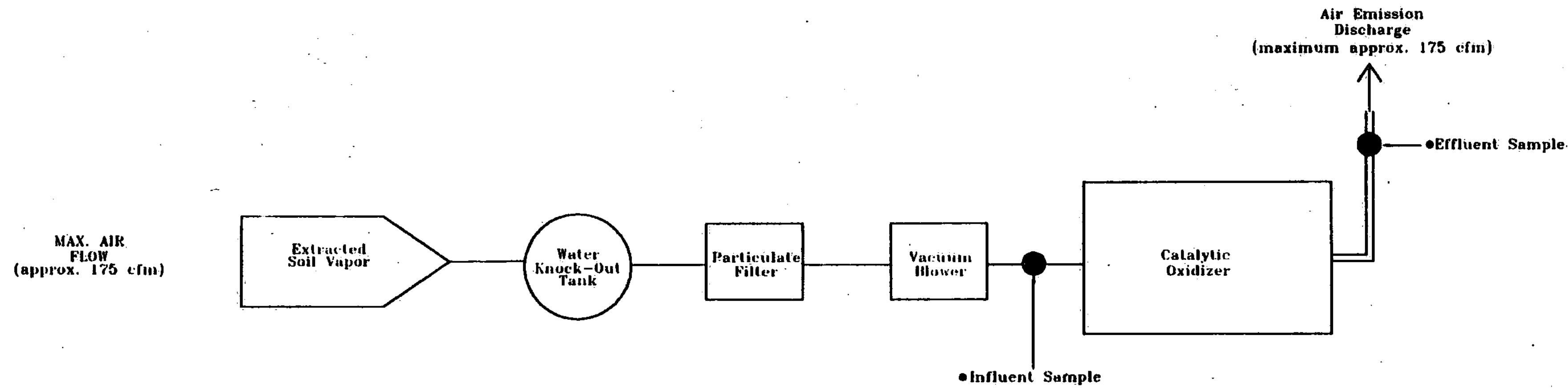
Time From Initial System Operation	Project Phase	Treatment System Component	Sample Location	Sampling/Monitoring Parameter	Sampling Frequency
0-2 weeks	Remedial Work Element II	Ground-Water	all on-site wells plus CHT-2, CHT-3, CHT-4, CHT-7D, MW-9S, MW-9, MW-10, MW-10D, G6, and G8	Liquid-level measurements	Daily
			MW-8, DW-1	Water level measurements	Continuous
			G-W Recovery Wells	Total gallons extracted	Daily
		Air Stripper (AS)	G-W Influent	VOCs via 8240 & 8270	Monthly (first 15 days)
		AS/TPDES	G-W Effluent	BTEX via 8240	Weekly
		AS/TPDES	G-W Influent/Effluent	TPH via 8015A	Weekly
		TPDES	G-W Influent/Effluent	lead via 7421	Weekly
		TPDES	G-W Effluent	pH via field meter, discharge flow rate	Weekly
		TPDES	G-W Effluent	TOC via 9060A, TSS via 160.2	Weekly
2-8 weeks	Remedial Work Element II	Ground-Water	all on-site wells plus CHT-2, CHT-3, CHT-4, CHT-7D, MW-9S, MW-9, MW-10, MW-10D, G6, and G8	Liquid-level measurements	Weekly
			MW-8, DW-1	Water level measurements	Continuous
			G-W Recovery Wells	Total gallons extracted	Weekly
			G-W Recovery Wells	Dissolved oxygen via field meter	Monthly
			G-W Recovery Wells	VOCs via 8240, TPH via 8015A	Monthly
			G-W Recovery Wells	Hardness via 130.2, iron via 6010B	One Event
			SW-1, SW-3, SW-8, SW-9, and SW-10	VOCs via 8240, TPH via 8015A	Monthly
		Air Stripper (AS)	G-W Influent	VOCs via 8240 & 8270	Monthly
		AS/TPDES	G-W Effluent	BTEX via 8240	Weekly
		AS/TPDES	G-W Influent/Effluent	TPH via 8015A	Weekly
		TPDES	G-W Influent/Effluent	lead via 7421	Weekly
		TPDES	G-W Effluent	pH via field meter, discharge flow rate	Weekly
		TPDES	G-W Effluent	TOC via 9060A, TSS via 160.2	Weekly
2-4 months	Remedial Work Element II	Ground-Water	all on-site wells plus CHT-2, CHT-3, CHT-4, CHT-7D, MW-9S, MW-9, MW-10, MW-10D, G6, and G8	Liquid-level measurements	Weekly
			MW-8, DW-1	Water level measurements	Continuous
			G-W Recovery Wells	Total gallons extracted	Monthly
			G-W Recovery Wells	Dissolved oxygen via field meter	Monthly
			G-W Recovery Wells	VOCs via 8240, TPH via 8015A	Monthly
			G-W Recovery Wells	Hardness via 130.2, iron via 6010B	Periodically
			SW-1, SW-3, SW-8, SW-9, and SW-10	VOCs via 8240, TPH via 8015A	Monthly
		Air Stripper (AS)	G-W Influent	VOCs via 8240 & 8270	Monthly
		AS/TPDES	G-W Effluent	BTEX via 8240	Monthly
		AS/TPDES	G-W Influent/Effluent	TPH via 8015A	Monthly
		TPDES	G-W Effluent	lead via 7421	Monthly
		TPDES	G-W Effluent	pH via field meter, discharge flow rate	Weekly
		TPDES	G-W Effluent	TOC via 9060A, TSS via 160.2	Weekly

VOCs = volatile organic compounds, TPH = total petroleum hydrocarbons, TOC = total organic carbon, TSS total suspended solids
Air stripper discharge is regulated by a DPNR Air Pollution Control Permit.

Table C-3
Initial Testing Program - Sample Summary Matrix
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Sample Type	Parameter	Analytical Parameter	Container and Preservative	Analysis Holding Time
Vapor	Volatiles	TO-14	Tedlar Bag N/A	N/A
Ground-Water	TCL Volatiles	8240	3-40 ml glass vials w/teflon lined enclosure Cool to $4^{\circ C}$	14 days
	TCL Semi-Volatiles	8270	1-liter amber glass w/teflon lined enclosure Cool to $4^{\circ C}$	14 days till extraction analyses w/i 40 days of extract preparation
	BTEX	8240B	3-40 ml glass vials w/teflon lined enclosure Cool to $4^{\circ C}$	14 days
	TPH- GRO, DRO	8015B	Same container as above.	14 days
	Lead	7421	1-liter plastic HNO3 to pH<2	180 days
	Iron	6010B	Same container as above	180 days
	Hardness	130.2	Same container as above	180 days
	TSS	160.2	500ml-plastic	14 days
	TOC	9060A	500ml-plastic	28 days

Figure C-1
Air Pollution Control
Soil Vapor Flow Diagram
Esso Tutu Service Station

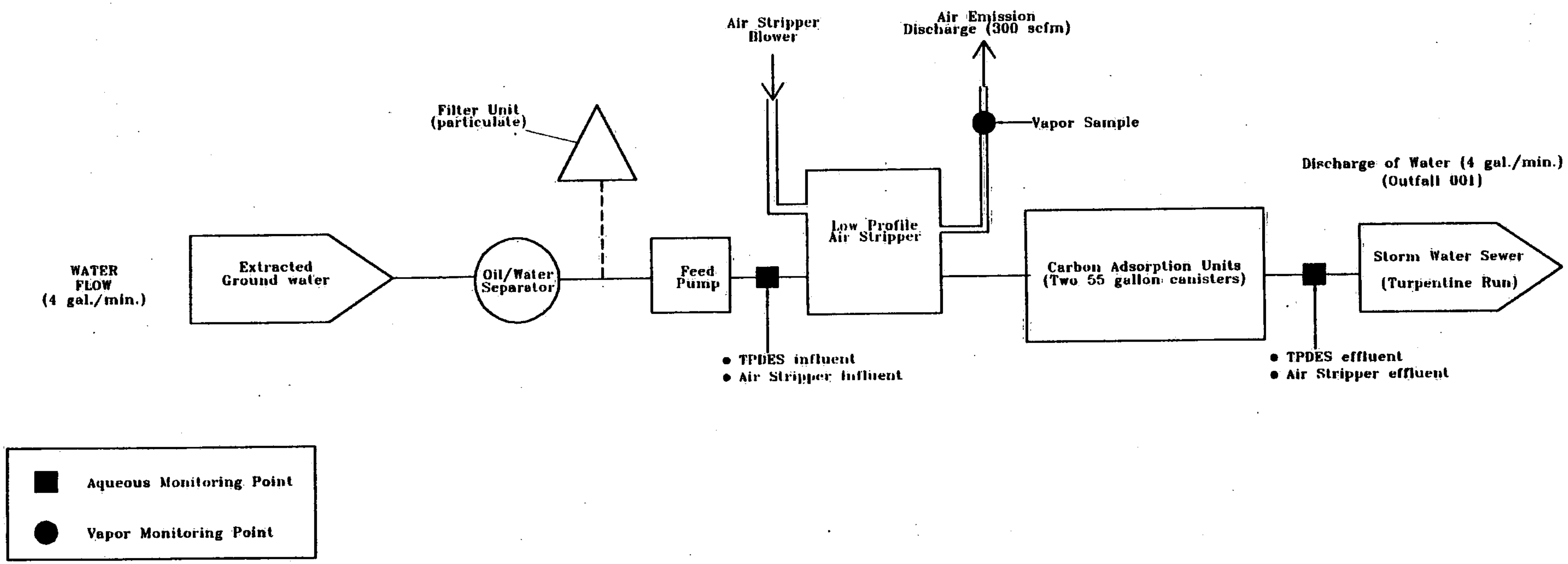


Notes:

1. Influent soil vapors will be sourced from five soil vapor extraction wells and five bioventing wells. Influent soil vapor will be treated by a catalytic oxidation unit.

SVEFLOW.DWG

Figure C-2
Air Pollution Control
Ground-Water Flow Diagram
Esso Tutu Service Station



Notes:

1. Influent water will be sourced from eight ground-water extraction wells (four overburden, 4 shallow bedrock).

2. Discharge of vapors from the air stripper will occur at a rate of approximately 300 cubic feet per minute (cfm).

TUTULINE.DWG

APPENDIX D
Site-Related Permits

FACT SHEET TPDES PERMIT VI0040703
[modified 04-29-98]

received
4/29/98

1. **Facility Name, Location, and Type:**
Permittee: ESSO TUTU SERVICE STATION GROUNDWATER REMEDIATION
TPDES Permit Number: VI0040703
Location: #384 Estate Anna's Retreat, St. Thomas, U.S. Virgin Islands

OUTFALL NO. 001 TURPENTINE RUN
Latitude: 18° 20' 26" North
Longitude: 64° 53' 19" West

Receiving Waters: Mangrove Lagoon is designated as Class "B" waters.
Facility Type: Ground Water Remediation Treatment Plant
SIC Code: Not Available
Point Source Category: AIR STRIPPER WITH POSSIBLE VAPOR PHASE GAC

2. **Discharge Quantity, Type, and Treatment:**

OUTFALL	DISCHARGE TYPE	FLOW	TREATMENT
001	TREATED GROUND WATER FROM EXISTING WELLS- SW-7, MW-9, & CHT-3.	14. 440 gpd.	AIR STRIPPER WITH CARBON ABSORPTION

TOTAL FLOW IS 14,440 gpd (0.014 MGD)

Post-it™ brand fax transmittal memo 7671 | # of pages ▸ 6
To Lehman | From Syedali
Co. | Co.
Dept. | Phone # 773 0565
Fax # 609 795 0574 | Fax #

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To Maguire | From Syedali
Co. | Co.
Dept. | Phone # 773 0565
Fax # 610 594 3943 | Fax #

Effluent Limitations and Monitoring Requirements:

Parameter	Basis for Effluent Limits
Flow:	BPJ based on Permit Application Form 2C.
pH	Water Quality Based Limitation (WQL); T. 12, Virgin Islands rules and Regulations, Ch. 7, Section 186-3 (b) (2).
Total Organic Carbon	BPJ based on EPA approved New Jersey Pollutant Discharge Elimination System/Discharge to Surface Water (NJPDES/DSW) Permit No. NJ0102709 General Petroleum Product Clean-up Permit.
Total Suspended Solids	BPJ based on Permit NO. NJ0102709
Benzene	40 CFR 141 sections 141.61a (Federal MCLs)
Toulene	BPJ based on Permit NO. NJ0102709
Total Xylene	BPJ based on Permit NO. NJ0102709
Total BTEX	DPJ based on Permit NO. NJ0102709
Lead	BPJ based on Permit NO. NJ0102709
Petroleum Hydrocarbons	BPJ based on Permit NO. NJ0102709

3. **Public Comment:**
See Original TPDES Permit No. VI0040703 dated February 21, 1997.

4. **Additional Information:**
See Original TPDES Permit No. VI0040703 dated February 21, 1997.

5. **Derivation of Effluent Limits:**

EFFLUENT LIMITATION AND MONITORING REQUIREMENT			
POLLUTANT	LIMIT	MONITORING FREQUENCY	SAMPLE TYPE
OUTFALL 001			
Flow	14,440 gpd	Weekly	Flow meter
pH	6.5 to 8.5	Weekly	Grab
Total Organic Carbon	20 mg/L	Weekly	Grab
Total Suspended Solids (TSS)	40 mg/L	Weekly	Grab
Benzene	15 ug/L	Monthly*	Grab
Toulene	50 ug/L	Monthly*	Grab
Total Xylene	50 ug/L	Monthly*	Grab
Total BTX	100 ug/L	Monthly*	Grab
Lead	50 ug/L	Monthly*	Grab
Petroleum Hydrocarbons	15 mg/L	Quarterly*	Grab

* Initial weekly monitoring of the groundwater remediation system influent and effluent for two months. After two months, Esso will submit a report documenting the results.

A. CONDITIONS OF PERMIT

This permit is issued subject to the following conditions:

- In addition to required the discharge monitoring report form [EPA #3320-1], monthly data reports for the first three months are required to be submitted by Esso on the operation of the treatment system including any and all groundwater monitoring and air emission data. Following the third month report submission, unless DPNR notifies Esso otherwise, reports and the operation of the treatment system may be reduced to quarterly. In addition, a comprehensive semi-annual report is required.

- Expedited QA/QC lab results (entire data package) will be submitted directly to DPNR within seven days after QA/QC review for the first two months of operation. Thereafter, results will be submitted within 14 days of QA/QC review.

B. EFFLUENT LIMITATION AND MONITORING REQUIREMENTS

During the period beginning EDP and lasting through EDP + 5 years, the Permittee is authorized to discharge from Outfall(s) serial number(s) 001.

Such discharges shall be limited and monitored by the Permittee as specified below:

EFFLUENT LIMITATION AND MONITORING REQUIREMENT			
POLLUTANT	LIMIT	MONITORING FREQUENCY	SAMPLE TYPE
OUTFALL 001			
Flow	14,400 gpd	Weekly	Flow meter
pH	6.5 to 8.5	Weekly	Grab
Total Organic Carbon	20 mg/L	Weekly	Grab
Total Suspended Solids (TSS)	40 mg/L	Weekly	Grab
Benzene	15 ug/L	Monthly*	Grab
Toulene	50 ug/L	Monthly*	Grab
Total Xylene	50 ug/L	Monthly*	Grab

Total BTX	100 ug/L	Monthly*	Grab
Lead	50 ug/L	Monthly*	Grab
Petroleum Hydrocarbons	15 mg/L	Quarterly*	Grab

There shall be no discharge of floating solids or visible foam in other than trace amounts.

Samples taken in compliance with the monitoring requirement specified above shall be taken at the following specified locations (s):

For influent: from sampling port prior to entry into the treatment system.

For effluent: any point after the treatment process but prior to being discharged into the receiving waters.

* Initial weekly monitoring of the groundwater remediation system influent and effluent for two months. After two months, Esso is to submit a report documenting the results.

NOTE:

NO BACKWASH FROM ANY TREATMENT UNIT(S) FOR MAINTENANCE PURPOSES OR ANY OTHER REASONS SHALL BE DISCHARGED THROUGH THE AUTHORIZED OUTFALLS.

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GOVERNMENT OF THE VIRGIN ISLANDS OF THE UNITED STATES

Department of Planning & Natural Resources
Division of Environmental Protection
WATER GUT HOMES 1118
CHRISTIANSTED, ST. CROIX 00820-5065
(809) 773-0565

September 3, 1998

Ms. Alicia Barnes
Barnes and Associates, Inc.
P.O. Box 879 Kingshill
USVI 00851

RE: Soil Boring Permit and Well Drilling Permit for Esso Standard Oil, Esso Tutu Service Station, St. Thomas, USVI

Dear Ms. Barnes,

The Department of Planning and Natural Resources - Division of Environmental Protection (DPNR-DEP) is processing Esso Standard Oil applications for soil boring/well drilling permits at the following locations:

1. 6 well drilling permits : Esso Tutu Service Station.
2. 2 well drilling permits : Four Winds Plaza property.
3. 2 well drilling permits : Four Winds Plaza property.
4. 4 well drilling permits : Esso Tutu Service Station.

As you are aware, the permits can only be issued by order of the Commissioner. At your request, and in the interest of expediting site characterization/remedial activities at the above referenced sites on St. Thomas, permission is hereby granted to Soil Tech Corp. (WDL-013-98) P.O.Box 1704, Hato Rey Station, Puerto Rico, by DPNR-DEP to proceed pending receipt of the official permits.

Please note that you must ensure that Soil Tech Corp.comply with the provisions of Act No. 1488, section 1, of the Virgin Islands Code (12 VIC §157), as amended, dealing with the licensing of well drilling as a regular business or as an incident to any line of business activity; and must comply with the provisions of the Civil Rights Act of the Virgin Islands (Act No. 720, approved June 9, 1961) [10 VIC §§ 41-44].

Please advise Esso and Soil Tech that they must also comply with the provisions of 12 VIC §161 when sealing the soil borings upon completion of site investigative activities. You must notify DPNR-DEP at least two days prior to commencement of drilling activities. This temporary permit is valid from September 3 to October 3, 1998, pending receipt of the official permits.

Sincerely,

Austin Moorehead

Austin Moorehead
Director, DPNR-DEP

Government Of
The Virgin Islands Of The United States

DEPARTMENT OF PLANNING & NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL PROTECTION
Charlotte Amalie, St. Thomas, Virgin Islands

AIR POLLUTION CONTROL

■ AUTHORITY TO CONSTRUCT   PERMIT TO OPERATE

For: **ESSO Virgin Islands, Inc.**
Airport Terminal
St. Thomas, Virgin Islands 00804

Permit No.:**STT-755-B-98**   Date: **July 15, 1998**

Persuant to the provisions of Title 12, Chapter 9, Section 206, Sub-Section 20 of the Virgin Islands Code. This Permit is issued to:

ESSO Virgin Islands Inc.

For the operation of the following: **One (1) Soil Vapor Extraction System.**

Located at: **384 Estate Anna's Retreat, St. Thomas, Virgin Islands**

In accordance with the application dated: **September 25, 1997** and in conformity with the statements and supporting data entered therein, all of which are filed with the Department and are considered a part of this permit.

This permit shall be effective from the date of : **July 15, 1998** for a two year period ending on: **July 15, 2000.**

Commissioner, DPNR

Government Of
The Virgin Islands Of The United States

DEPARTMENT OF PLANNING & NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL PROTECTION
Charlotte Amalie, St. Thomas, Virgin Islands

AIR POLLUTION CONTROL

AUTHORITY TO CONSTRUCT ■ PERMIT TO OPERATE

For: **ESSO Virgin Islands, Inc.**
Airport Terminal
St. Thomas, Virgin Islands 00804

Permit No.:**STT-755-A-98** Date: **July 15, 1998**

Persuant to the provisions of Title 12, Chapter 9, Section 206, Sub-Section 20 of the Virgin Islands Code. This Permit is issued to:

ESSO Virgin Islands Inc.

For the operation of the following: **One (1) Shallow Tray Model 1330/1331 groundwater air stripper.**

Located at: **384 Estate Anna's Retreat, St. Thomas, Virgin Islands**

In accordance with the application dated: **September 25, 1997** and in conformity with the statements and supporting data entered therein, all of which are filed with the Department and are considered a part of this permit.

This permit shall be effective from the date of : **July 15, 1998** for a two year period ending on: **July 15, 2000.**

Commissioner, DPNR

Forensic Environmental Services, Inc.
113 John Robert Thomas Drive
The Commons at Lincoln Center
Exton, Pennsylvania 19341

Telephone: (610) 594-3940 Telecopier: (610) 594-3943

24 September 1998

Mr. Winston M.A. Williams Jr.
Air Pollution Control Program Supervisor
Department of Planning and Natural Resources
Foster Plaza 396-1
Anna's Retreat
St. Thomas, USVI 00802

Re: Soil Vapor Extraction Unit (A/C)
Ground-Water Air Stripper (A/C)
"Authority to Construct" Permit Nos. STT-755-A-98 and STT-755-B-98
Esso Tutu Service Station Remedial System

Dear Mr. Williams:

Forensic Environmental Services, Inc. (FES), on behalf of Esso Virgin Islands, Inc. (Esso), has received and reviewed the "Authority to Construct" Soil Vapor Extraction System and Ground-Water Air Stripper Air Pollution Control Permits issued on 15 July 1998 by the USVI Department of Planning and Natural Resources (DPNR) for the referenced site. After reviewing the permits, it is noted that modifications have been made to the original remedial system design/capacity since the original application was prepared and submitted to DPNR by FES on 25 September 1997. These alterations were the result of discussions between the U.S. EPA, DPNR, Esso, and FES, and were made with full regulatory approval.

As a result of the remedial system design/capacity changes, several revisions will be necessary to the two "Authority to Construct" Permit Nos. STT-755-A-98 and STT-755-B-98. The changes to the remedial system and the consequent effect on the applications and permits are outlined below. For your convenience, a copy of the original permit applications and Permit Nos. STT-755-A-98 and STT-755-B-98 are attached. Revised permit applications have been submitted in triplicate.

SOIL VAPOR EXTRACTION SYSTEM - AIR POLLUTION CONTROL PERMIT

The Soil Vapor Extraction (SVE) System will utilize 5 extraction wells operating at 15 to 20 cubic feet per minute (cfm) per well, and five biovent extraction (BE) wells operating at flow rates ranging from 3-5 cfm each. The expected average operating total flow for the SVE system will be 125 cfm with a maximum estimated flow rate of approximately 175 cfm. Vapor treatment for the SVE System will be provided by a catalytic-oxidizer (cat-ox) unit instead of vapor-phase carbon as specified in the original application.

Table 1a presents air emissions calculations based on average soil vapor concentrations obtained during on-site pilot testing at the expected average operating flow rate of 125 cfm and at the maximum SVE system capacity flow rate of 175 cfm. Table 1b presents air emissions calculations based on maximum soil vapor concentrations obtained during on-site pilot testing at flow rates of 125 cfm and 175 cfm. The latter conditions serve as the "worst-case" scenario (regarding maximum mass loading) for the SVE system. The cat-ox unit is designed to operate at a minimum removal efficiency of 95%; this will reduce projected contaminant concentrations in the vapor effluent to 0.043 lbs/hour at an SVE flow rate of 175 cfm.

A revised permit application, which includes equipment description, emissions calculations (Tables 1a and 1b), manufacturer's equipment specifications sheets, system schematic, and a process and instrumentation diagram (P&ID), is enclosed. The changes described above have resulted in the following modifications to the soil vapor extraction permit application and permit (original application and permit attached):

<u>application:</u>

SECTION A, ITEM 1:	"new process equipment and new air pollution control apparatus" is now selected
SECTION A, ITEM 3:	starting date October 1998, Est. completion 2002
SECTION B, ITEM 2:	vacuum blower, cat-ox unit
SECTION B, ITEM 3:	0.043 total pounds per hour
SECTION C:	(see Table 1c attached to permit application)
SECTION D, ITEM 1:	moisture knock-out, in-line filter, catalytic oxidation unit
SECTION D, ITEM 2:	minimum of 95%
SECTION D, ITEM 3:	approximately 15 feet
SECTION D, ITEM 4:	9.5 ft.
SECTION D, ITEM 5:	avg. 125 cfm, max. 175 cfm
SECTION D, ITEM 6:	560 ft. per minute
SECTION D, ITEM 7:	600°
SECTION D, ITEM 8:	Yes
SECTION D, ITEM 9:	N/A
SECTION D, ITEM 10:	$40,000

air pollution control permit:

SECTION II, ITEM f:	change to concentrations listed in this revision
SECTION II, ITEM g:	the maximum flow rate should be 10 gpm
SECTION II, ITEM k:	eliminate (no vapor-phase air control)
SECTION II, ITEM l:	eliminate (no vapor-phase air control)
SECTION II, ITEM m:	eliminate (no vapor-phase air control)
SECTION II, ITEM n:	eliminate (no vapor-phase air control)

FES greatly appreciates your prompt attention to this matter. It is our understanding that DPNR will be able to provide FES with a telefax copy of the revised permit within five business days of the receipt of this submission. Please contact us at your earliest convenience if this time frame is not possible. If you have any questions or concerns about the information provided here, please feel free to call us at 610-594-3940.

Sincerely,

FORENSIC ENVIRONMENTAL SERVICES, INC.

Robert Zei

Robert W. Zei
Senior Hydrogeologist

Nick DeSalvo

Nick DeSalvo
Senior Project Manager

Attachments

cc: Giancarlo Villa, Esso Virgin Islands, Inc.
Carlos Figueroa, Esso Standard Oil Company (Puerto Rico)
Chad Stevens, Esso Virgin Islands, Inc.

permit:

INTRODUCTION:	substitute "catalytic oxidizer" for "vapor-phase carbon"
SECTION II, ITEM a:	change maximum flow rate of air to from 162.5 scfm to 175 scfm
SECTION II, ITEM c:	(no change - already lists cat-ox)

GROUND-WATER AIR STRIPPER - AIR POLLUTION CONTROL PERMIT

The Ground-Water Extraction (GWE) System will utilize 4 perched water and 4 shallow bedrock ground-water extraction wells. Ground-water extraction rates are expected to range from 0.25 to 0.50 gallons per minute (gpm) for each perched water well, and from 0.50 to 1.0 gpm for each shallow bedrock well (total flow rate of 6 gpm), The expected initial operating flow for the GWE system will be 6 gpm with a maximum estimated flow rate of approximately 10 gpm. During the operational life of the system, total process flow rates are expected to decrease as the perched water zone is dewatered.

Ground water will be processed through a treatment system that includes an oil/water separator, sediment filter, and a low-profile ground-water air stripper. Aqueous-phase granular activated carbon treatment is added as a precautionary measure. Off-gas from the ground-water air stripper will be discharged directly to the atmosphere. The ground-water air stripper is designed to operate at a maximum air flow discharge rate of 300 scfm. The estimated total concentration of volatile organic compounds in the air stripper off-gas under normal operating conditions is 0.08 lbs/hour, and 0.13 lbs/hour at the maximum extraction rate of 10 gpm. Air emission calculations for the air stripper are provided in Table 2a.

A revised permit application, which includes equipment description, emissions calculations (Tables 1a and 1b), manufacturer's equipment specifications sheets, system schematic, and a P&ID, is enclosed. The changes described above have resulted in the following modifications to the ground-water air stripper air pollution control permit application and permit (original application and permit attached):

application:

SECTION A, ITEM 3:	starting date October 1998, Est. completion 2008
SECTION B, ITEM 3:	0.08 total pounds per hour
SECTION C:	(see Table 2b attached)
SECTION D, ITEM 1:	substitute "NONE" for "Dual-Bed Granular Activated Carbon system" (This entry was in error in the original application. Due to the de minimus mass discharge neither the original or the revised application incorporated off-gas treatment.)
SECTION D, ITEM 2:	N/A
SECTION D, ITEM 5:	300 cu. ft. per min.
SECTION D, ITEM 6:	1500 ft. per min.
SECTION D, ITEM 7:	80°

air pollution control permit:

SECTION II, ITEM f:	change to concentrations listed in this revision
SECTION II, ITEM g:	the maximum flow rate should be 10 gpm
SECTION II, ITEM k:	eliminate (no vapor-phase air control)
SECTION II, ITEM l:	eliminate (no vapor-phase air control)
SECTION II, ITEM m:	eliminate (no vapor-phase air control)
SECTION II, ITEM n:	eliminate (no vapor-phase air control)

FES greatly appreciates your prompt attention to this matter. It is our understanding that DPNR will be able to provide FES with a telefax copy of the revised permit within five business days of the receipt of this submission. Please contact us at your earliest convenience if this time frame is not possible. If you have any questions or concerns about the information provided here, please feel free to call us at 610-594-3940.

Sincerely,

FORENSIC ENVIRONMENTAL SERVICES, INC.

Robert W. Zei
Senior Hydrogeologist

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Senior Project Manager

Attachments

cc: Giancarlo Villa, Esso Standard Oil Company (Puerto Rico)
Carlos Figueroa, Esso Standard Oil Company (Puerto Rico)
Chad Stevens, Esso Virgin Islands, Inc.

GOVERNMENT OF
THE VIRGIN ISLANDS OF THE UNITED STATES
DEPARTMENT OF PLANNING AND NATURAL RESOURCES
AIR POLLUTION CONTROL

APPLICATION

AUTHORITY TO CONSTRUCT AND PERMIT TO OPERATE

INSTRUCTIONS

A. This application must be filled out completely and must be filed in TRIPLICATE.

B. Applications are incomplete unless accompanied by DUPLICATE copies of all plans, specifications and drawings required. Details required for specific equipment are listed on separate forms which are available upon request.

INCOMPLETE APPLICATIONS ARE NOT ACCEPTABLE

Date of Application: REVISED SEPT. 24, 1998

APPLICATION INFORMATION

1. Permit to be issued to: (Business License Name of Corporation, Company, Individual Owner or Governmental Agency that is to operate the Equipment):

   ESSO VIRGIN ISLANDS, INC

2. Mailing Address:

   P.O. Box ESSO TERMINAL City CHARLOTTE AMALIE Island ST. THOMAS Zip 00801

3. Address at which the equipment is to be operated:

   Number 384 Street ESTATE ANNA'S RETREAT Island ST. THOMAS Zip 00802

4. Type of Organization: Corp. X Partnership ____ Individual Owner ____ Governmental Agency ____

5. General Nature of Business:

   PETROLEUM RETAIL SERVICE STATION

6. Equipment Description: Pursuant to the Provisions of the U.S. Virgin Islands Code and the Rules and Regulations of the Air Pollution Control Region, application is hereby made for authority to construct and permit to operate the following equipment:

   AIR STRIPPER GROUND-WATER TREATMENT UNIT
   (ESSO TUTU GROUND-WATER REMEDIATION)

Sec. A	1. ☐ New process equipment and new air pollution control apparatus ☐ New air pollution control apparatus on existing process equipment ☒ New process equipment with no control apparatus ☐ Other: ______ 2. Prior permit numbers covering this installation. Specify. NOT APPLICABLE 3. Estimated starting date OCTOBER 1998 Est. completion 2008
Sec. B	1. Description of operation AIR STRIPPER TREATMENT FOR REMEDIATION OF GROUND WATER 2. Identify process equipment AIR STRIPPER 3. Raw materials (names) GROUND WATER CONTAMINATED WITH PETROLEUM PRODUCT Total pounds per hour 0.08 Total pounds per batch — (SEE ATTACHED TABLE 2A) 4. Operating procedure: ☒ Continuous: 24 hrs. per day 7 days per ☒ week ☐ month ☐ Batch: — hrs. per batch — batches per ☐ day ☐ week
	Physical and chemical nature of air contaminants which must evolve from operation and be emitted into the open air:

Sec. C	Air Contaminants	Amounts of Contaminants	
		With Control Apparatus	Without Control Apparatus
	(SEE ATTACHED TABLE 2B		
	FOR A COMPLETE LIST OF POTENTIAL		
	AIR CONTAMINANTS)		

Sec. D	
	1. Describe air pollution control apparatus NONE
	2. Efficiency of control apparatus: 99.9 %
	3. Height of discharge above ground 20 ft.
	4. Distance from discharge to nearest property line APPROX. 15 ft.
	5. Volume of gas discharged into open air 300 cu. ft. per min. at stack conditions.
	6. Exit linear velocity at point of discharge 1500 ft. per min. at stack conditions.
	7. Temperature at point of discharge 80 °F.
	8. Will emissions comply with existing local requirements? YES
	9. Initial cost of control apparatus $ 15,000
	10. Estimated annual operating cost $ 2,500

This application is submitted in accordance with the provisions of the Virgin Islands Code 12, Chapter 9, Air Quality Control Regulations Section 206-20, and to the best of my knowledge and belief is true and correct.

ESSO VIRGIN ISLANDS INC
CYRIL E. KING
AIRPORT TERMINAL

ST. THOMAS USVI
Mailing Address

00804
Zip Code

Signature - all copies

Name (print or type)

Title

Telephone No.

AUTHORITY TO CONSTRUCT AND PERMIT TO OPERATE

[illegible] APPROVED

Date [illegible] Approved by [illegible]

Permit No. [illegible] Supervisor, Permits and Certification [illegible]

Esso Tutu Service Station
Ground-Water Remedial System
Air Pollution Control Permit
Equipment Description

System Description

As part of the USEPA CERCLA Record of Decision, Esso Virgin Islands, Inc. is required to remediate shallow ground water beneath the Esso Tutu Service Station. The subject site is located on Route 38, Anna's Retreat, St. Thomas, adjacent to Four Winds Plaza (Figure 1).

The proposed remedial program will involve the extraction of ground water from four overburden and four shallow bedrock wells. The four overburden wells will be installed to a depth of approximately 15 feet and utilized to extract ground water at a rate of 0.5 gallons per minute (gpm) per well (total overburden flow rate of 2.0 gpm). The four shallow bedrock wells will be installed to a depth of approximately 60 feet and utilized to extract ground water at a rate of 1.0 gallons per minute (gpm) per well (total shallow bedrock flow rate of 4.0 gpm). During initial operation, the expected ground-water extraction rate will be approximately 6.0 gpm (the SVE moisture knock-out system may also contribute up to 1.0 gpm) with a maximum anticipated flow rate of 10 gpm. Total process flow rates are expected to decline over time as the overburden is dewatered.

Extracted ground water will be transferred to an oil/water separator, facilitating the separation of phase-separated hydrocarbons (if present) and water. Phase-separated hydrocarbons (if present) will be disposed in accordance with USEPA and DPNR protocol. Ground water will be directed to a batch holding tank and processed through a treatment system that will involve the following components:

1. Sediment filter,
2. Low profile air stripper, and
3. Aqueous-phase granular activated carbon.

The above components are illustrated in the attached "Process Flow Diagram" and "Process & Instrumentation Diagram".

Equipment Description

The air stripper unit is the only component of the ground-water remedial system that will emit gases to the atmosphere. A ShallowTray-brand Model 2341 will be utilized for the Esso Tutu treatment system. A discharge pipe will be attached to the air stripper to elevate the point of emission to a height of 20 feet above ground surface.

Calculations summarizing expected effluent concentrations in the air stripper off-gas are included in Table 2a. Assuming 100% air stripper efficiency ("worst-case with respect to maximum atmospheric mass loading), these calculations indicate that the concentration of total volatile organic compounds in the off-gas stream will be approximately 0.078 pounds per hour during average flow (6 gpm), and a maximum of 0.130 pounds per hour during maximum flow (10 gpm). Compliance monitoring will include the collection of aqueous-phase samples for analytical testing at the same frequency as that outlined in the TPDES Permit #VI0040703 for the site. A schedule for compliance monitoring during the first 12 months of system operation is presented in Table 2c. The emission rate will be calculated on a monthly basis using the following equation:

$$\text{Max. Emission Rate (\#/hr)} = \text{Max. Flow (gal/min)} \times \text{Max. Concentration (ppm)} \times 8.34\ (\text{\#/gal}) \times 60\ (\text{min/hr}) \times 10^{-6}$$

Air stripper off-gas will be discharged directly to the atmosphere. Off-gas concentrations will be field-monitored during operation of the remedial system to ensure that effluent concentrations do not significantly exceed those predicted. DPNR will be copied on all air emission monitoring data.

Table 2a
Air Emissions Calculations
Ground-Water Extraction System (Air Stripper Off-Gas)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Compound	Weighted Flow Concentration			Contaminant Mass @ 10 gpm			Total Contaminant Mass (lbs/hr)	
	μg/L	mg/L	gm/L	gm/gal	gm/min	gm/hr	6 gpm	10 gpm
Benzene	2222	2.222	0.0022	0.0084	0.0841	5.0456	0.0070	0.0116
Toluene	134	0.134	0.0001	0.0005	0.0051	0.3036	0.0004	0.0007
Ethylbenzene	684	0.684	0.0007	0.0026	0.0259	1.5541	0.0021	0.0036
Xylenes	1856	1.856	0.0019	0.0070	0.0702	4.2144	0.0058	0.0097
MTBE	19939	19.939	0.0199	0.0755	0.7547	45.2813	0.0624	0.1040
Tetrachloroethene	12	0.012	1.20E-05	4.54E-05	0.0005	0.0273	3.75E-05	0.0001
Trichloroethene	3	0.003	3.00E-06	1.14E-05	0.0001	0.0068	9.39E-06	1.56E-05
1,2 Dichloroethene (total)	23	0.023	2.30E-05	0.0001	0.0009	0.0522	0.0001	0.0001
Vinyl Chloride	3	0.003	3.00E-06	1.14E-05	0.0001	0.0068	9.39E-06	1.56E-05
Acetone	2	0.002	2.00E-06	7.57E-06	0.0001	0.0045	6.26E-06	1.04E-05
Methylene Chloride	14	0.014	1.40E-05	0.0001	0.0005	0.0318	4.38E-05	0.0001
	A	B = A/1000	C = B/1000	D = Cx3.785	E = Dx10	F = Ex60	G = H/0.6	H = F/435.5
Total estimated air emission in pounds/hour (assumes 100% air stripper efficiency) =							**0.078**	**0.130**

L = liters, μg = microgram, mg = milligrams, gm = grams, gal = gallons, gpm = gallons per minute, min = minutes, lbs = pounds, hr = hour
Weighted flow concentrations assume the four "perched water" wells will provide 33% of the total flow and the four "deep" wells will provide 67% of the total flow.
Weighted contaminant concentrations based on quantitative ground-water samples collected at the site in September/October 1996.
Estimate assumes air stripper will operation with a 100% treatment efficiency.

Table 2b
Air Emissions Calculations
Ground-Water Extraction System (Air Stripper Off-Gas)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

SECTION C			
Air Contaminants	Amounts of Contaminants		
	With Control Apparatus (lbs/hr)	Without Control Apparatus (lbs/hr)	
		6 gpm	10 gpm
Benzene	not applicable	0.0070	0.0116
Toluene	not applicable	0.0004	0.0007
Ethylbenzene	not applicable	0.0021	0.0036
Xylenes	not applicable	0.0058	0.0097
MTBE	not applicable	0.0624	0.1040
Tetrachloroethene	not applicable	3.75E-05	0.0001
Trichloroethene	not applicable	9.39E-06	1.56E-05
1,2 Dichloroethene (total)	not applicable	0.0001	0.0001
Vinyl Chloride	not applicable	9.39E-06	1.56E-05
Acetone	not applicable	6.26E-06	1.04E-05
Methylene Chloride	not applicable	4.38E-05	1.00E-04
TOTAL	not applicable	0.08	0.13

Assumptions used to estimate discharge in pounds per hour (lbs/hr) are identified in Table 2a.
Average operational system flow rate is estimated at 6 gallons per minute (gpm); maximum estimated system flow rate is 10 gpm.

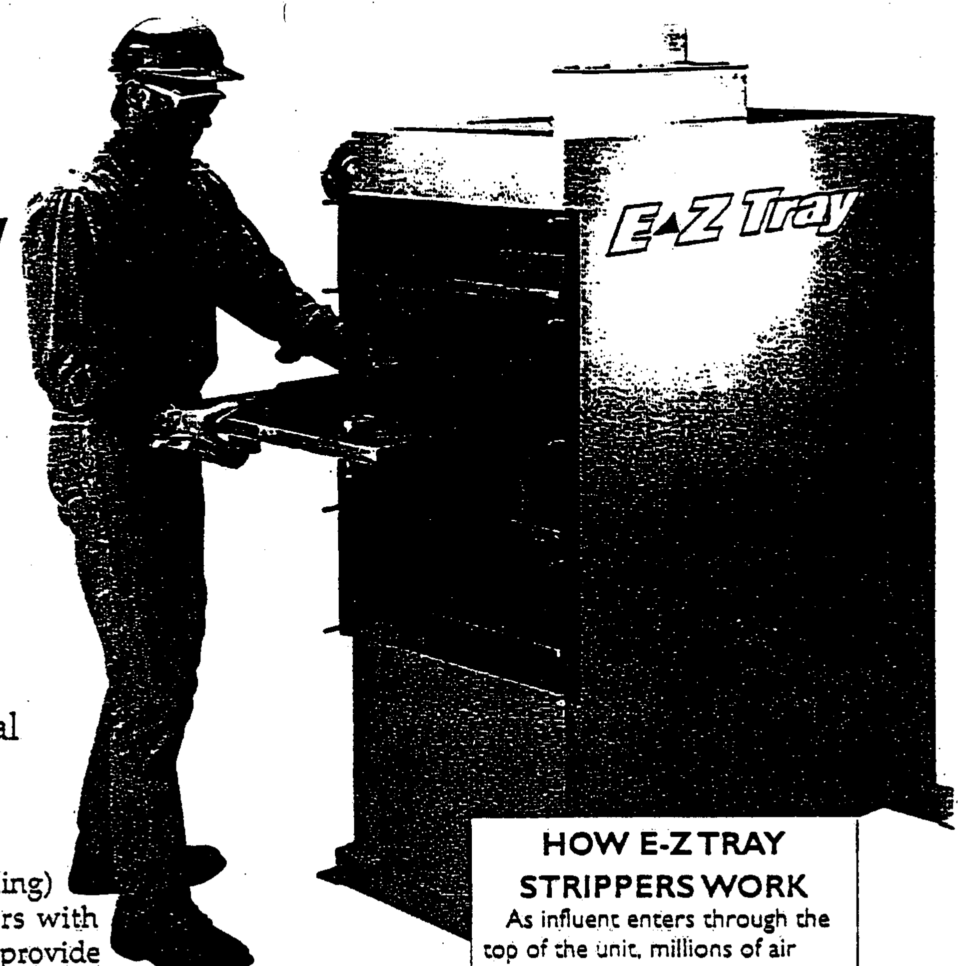
Table 2c
Schedule of Compliance Monitoring
Ground-Water Extraction System (Air Stripper Off-Gas)
Air Pollution Control Permit
Esso Tutu Service Station
St. Thomas, U.S.V.I.

	Sampling Frequency
Time From System Start-up	**Quantitative Sampling (Aqueous Phase) (Laboratory)**
0 - 2 months	Weekly; influent and effluent for VOCs and TPH
2 months - 6 months	Monthly; influent and effluent for VOCs and TPH
6 months - 12 months	Monthly; influent and effluent for VOCs Quarterly; influent and effluent for TPH

VOCs = volatile organic compounds (analysis via EPA Method 8240)
TPH = total petroleum hydrocarbons (analysis via EPA Method 8015A)
influent = pre-air stripper aqueous sample; effluent = system discharge aqueous sample
Influent and effluent aqueous-phase samples will be used to calculate the contaminant mass removed and discharged in the vapor-phase by the air stripper.
The sampling frequency outlined above is based on ground-water system discharge sampling requirements stipulated in the site's TPDES Permit #VI0040703.

E-Z Tray™

Removable Tray Air Strippers



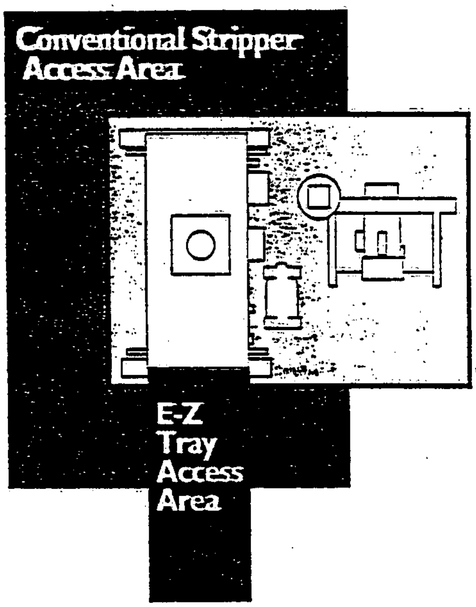
UNIQUE FRONT ACCESS DESIGN PROVIDES LONG-TERM O&M SAVINGS

- Single-person cleaning
- Easy accessibility
- Space and construction cost savings
- High-efficiency VOC removal

THE MOST PRACTICAL, ECONOMICAL STRIPPERS

E-Z Tray™ air strippers (patent pending) are the only high-performance strippers with lightweight, front-slideout trays. They provide many advantages:

- One-person cleaning can save thousands of dollars per year on cleaning costs.
- Front serviceability—with just 4" clearance required at back and sides—allows positioning in corners, tight access or low clearance locations—saving thousands more by cutting building space needs 10-40%.
- Forced-draft air bubble technology delivers rapid, efficient VOC removal (to 99.999%) and generates a self-cleaning action that fights fouling.



MODELS TO FIT YOUR NEEDS, SPACE, AND BUDGET

E-Z tray strippers are available in four or six-tray configurations, with maximum flow ratings from 1-25 GPM (4-100 LPM) through 1-150 GPM (4-600 LPM).

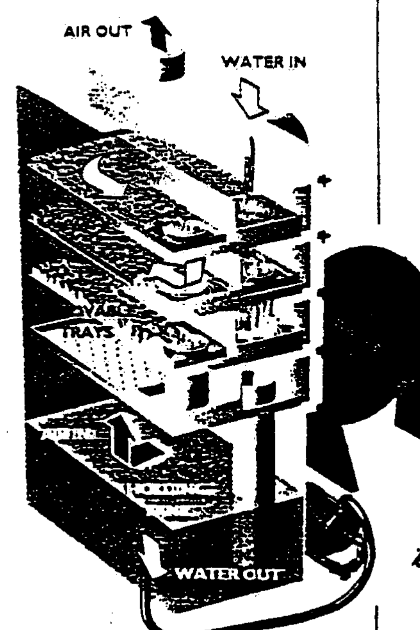
Call today to talk to a QED Applications Specialist about which E-Z Tray Stripper is right for your project—<u>and find out how much you'll save.</u>

UP-TIME CERTIFIED TREATMENT EQUIPMENT

800-624-2026

HOW E-Z TRAY STRIPPERS WORK

As influent enters through the top of the unit, millions of air bubbles are forced by the blower pressure up through the perforated trays, vigorously aerating the water to a froth and removing volatile contaminants as gravity pulls the water down through each tray. This simple, revolutionary technology delivers up to 99.999% removal, while the low maintenance and easy access cut O & M costs dramatically.



QED *Environmental Systems, Inc.* 6095 Jackson Road, P.O. Box 3726, Ann Arbor, MI 48106
313-995-2547 FAX 313-995-1170

E-Z Tray™

STANDARD ITEMS

- One Piece Shell with Integral Sump
- Stainless Steel Trays
- Quick-Access Front Hatch Assembly
- Clear PVC Liquid Level Sight Gauge
- Poly Mesh Demister
- Pre-Piping
- Epoxy Coated Mild Steel Construction

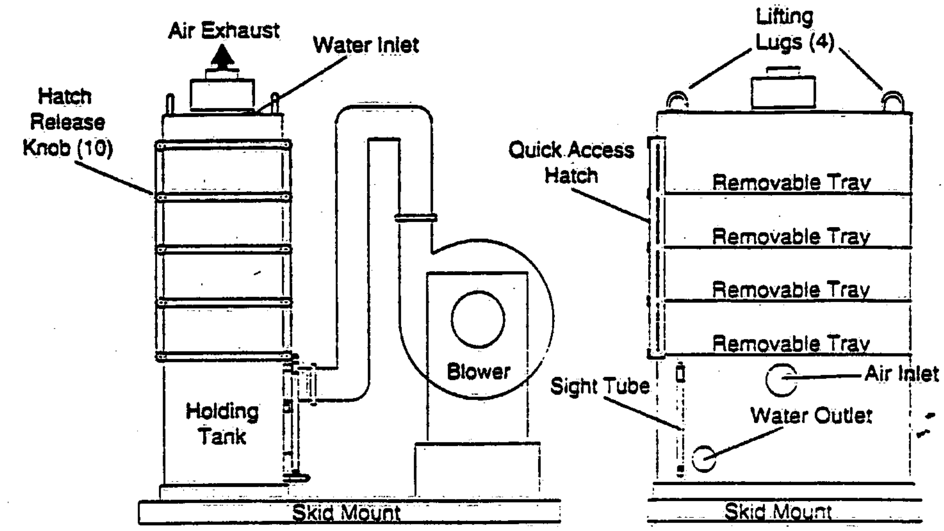
E-Z TRAY OPTIONS

- EXP or TEFC Blower & Pump Motors
- Spare Trays
- Control Panel
- Effluent Pump
- Pump Controls
- Additional Fittings
- Temp & Pressure Gauges
- Water Flow Meter
- Air Flow Meter
- Pre-Wiring
- Intrinsically Safe Sensors
- Base Unit Pre-plumbed to Blower
- Skid Mounting
- Stainless Steel Shell Construction
- Six Tray units

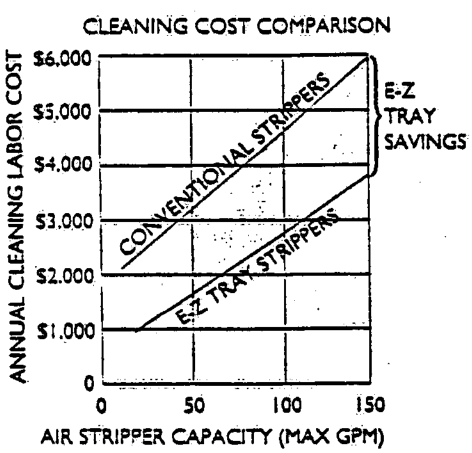
EZ TRAY AIR STRIPPER SPECIFICATIONS

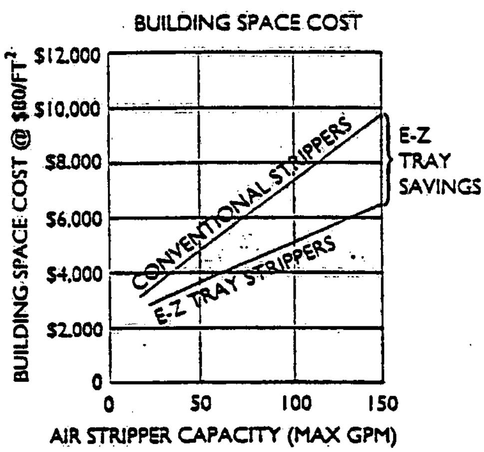
Model	Dimensions (in inches) H	L	W	Dry Wt.	Oper Wt.	Dry Wt. Per Tray	Flow Range (GPM)
4.4	80.50	29.0	30	630 lbs	985 lbs	29 lbs	1-25
6.4	80.50	38.5	30	790 lbs	1285 lbs	40 lbs	1-35
8.4	80.75	50.5	30	955 lbs	1,580 lbs	50 lbs	1-50
12.4	81.00	75.0	30	1,165 lbs	2,105 lbs	74 lbs	1-75
16.4	81.00	50.5	55	1,625 lbs	2,870 lbs	50 lbs	1-100
24.4	81.00	75.0	55	2,100 lbs	3,980 lbs	74 lbs	1-150

Note: Specifications are for standard four-tray models. Consult factory for six-tray model specifications.



COST COMPARISON GRAPHS





Note: These are average cleaning costs, based on moderate levels of fouling requiring 12 cleanings per year at a labor cost of $40.00/hour. Actual cost will vary depending on changes in these factors. This graph assumes every other Latch-Tray cleaning will require full disassembly, with internal spray-wand cleaning only in alternate months. Each E-Z Tray cleaning includes tray removal.

STANDARD HOOK-UP REQUIREMENTS

Model	Water Inlet	Water Outlet	Blower Inlet	Exhaust Outlet	Water Gauge/Drain	Blower HP (Std.)
4.4	2" FNPT	3" FNPT	4" Flange	4.50" O.D. Pipe	1" FNPT	3.0 HP
6.4	3" FNPT	4" FNPT	6" Flange	6.63" O.D. Pipe	1" FNPT	5.0 HP
8.4	3" FNPT	4" FNPT	6" Flange	6.63" O.D. Pipe	1" FNPT	5.0 HP
12.4	4" FNPT	4" FNPT	6" Flange	6.63" O.D. Pipe	1" FNPT	7.5 HP
16.4	6" FNPT	4" FNPT	6" Flange	6.63" O.D. Pipe	1" FNPT	7.5 HP
24.4	6" FNPT	6" FNPT	8" Flange	8.63" O.D. Pipe	1" FNPT	15 HP

EZ Tray System Specification Data

Fill in and fax this section to QED to help determine which model & accessories will best meet your project needs.

SITE NAME AND LOCATION (optional) ____________

SITE TYPE (gas station, landfill, factory, etc.) ____________

NAME ____________

COMPANY ____________

ADDRESS ____________

CITY ____________

STATE / ZIP ____________

PHONE ____________

FAX ____________

Maximum system flow (gpm) ______

Water temperature (°F) ______

Air temperature (°F) ______

Contaminants	Influent (ppb)	Effluent Req'd
Benzene	____	____
Toluene	____	____
Ethylbenzene	____	____
Xylene	____	____
____	____	____
____	____	____
____	____	____

Stripper material:
- ☐ Epoxy/steel ☐ HDPE
- ☐ Stainless steel

Air discharge treatment: ☐ Yes ☐ No
- ☐ Vapor phase carbon
- ☐ Thermal or catalytic oxidation

Iron sequestering agent ☐ Yes ☐ No

Site concerns ____________
(noise, access, etc.)

QED Environmental Systems, Inc. 6095 Jackson Road, P.O. Box 3726, Ann Arbor, MI 48106
313-995-2547 FAX 313-995-1170

ShallowTray
low profile air strippers

DRAFT

System Performance Estimate

Client and Proposal Information:

Forensic Environmental

Model Chosen:	2300
Water Flow Rate:	10.0 gpm
Air Flow Rate:	300 cfm
Water Temp:	60.0 F
Air Temp:	60.0 F
A/W Ratio:	224.4
Safety Factor:	None

Contaminant	Untreated Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent * Water Air(lbs/hr) % removal
Benzene	2250 ppb 15 ppb	30 ppb 0.011105 98.6701%	1 ppb 0.011250 99.9823%	<1 ppb 0.011255 99.9998%	<1 ppb 0.011255 100.0000%
MTBE	20000 ppb 1000 ppb	4364 ppb 0.078214 78.1819%	953 ppb 0.095277 95.2397%	208 ppb 0.099004 98.9614%	45 ppb 0.099814 99.7734%
p-Xylene	1900 ppb 50 ppb	25 ppb 0.009379 98.7294%	1 ppb 0.009499 99.9839%	<1 ppb 0.009504 99.9998%	<1 ppb 0.009504 100.0000%
Toluene	150 ppb 50 ppb	3 ppb 0.000735 98.3680%	<1 ppb 0.000750 99.9734%	<1 ppb 0.000750 99.9996%	<1 ppb 0.000750 100.0000%
Ethyl Benzene	700 ppb 50 ppb	8 ppb 0.003462 98.8798%	<1 ppb 0.003501 99.9874%	<1 ppb 0.003502 99.9999%	<1 ppb 0.003502 100.0000%
Trichloroethylene	5 ppb 1 ppb	<1 ppb 0.000025 99.7067%	<1 ppb 0.000025 99.9991%	<1 ppb 0.000025 100.0000%	<1 ppb 0.000025 100.0000%
Tetrachloroethylene	15 ppb 1 ppb	<1 ppb 0.000075 99.8327%	<1 ppb 0.000075 99.9997%	<1 ppb 0.000075 100.0000%	<1 ppb 0.000075 100.0000%
1,1-Dichloroethylene	25 ppb 1 ppb	<1 ppb 0.000124 99.4946%	<1 ppb 0.000125 99.9974%	<1 ppb 0.000125 100.0000%	<1 ppb 0.000125 100.0000%
Vinyl Chloride	5 ppb 1 ppb	<1 ppb 0.000025 99.9822%	<1 ppb 0.000025 100.0000%	<1 ppb 0.000025 100.0000%	<1 ppb 0.000025 100.0000%

Page 2

DRAFT

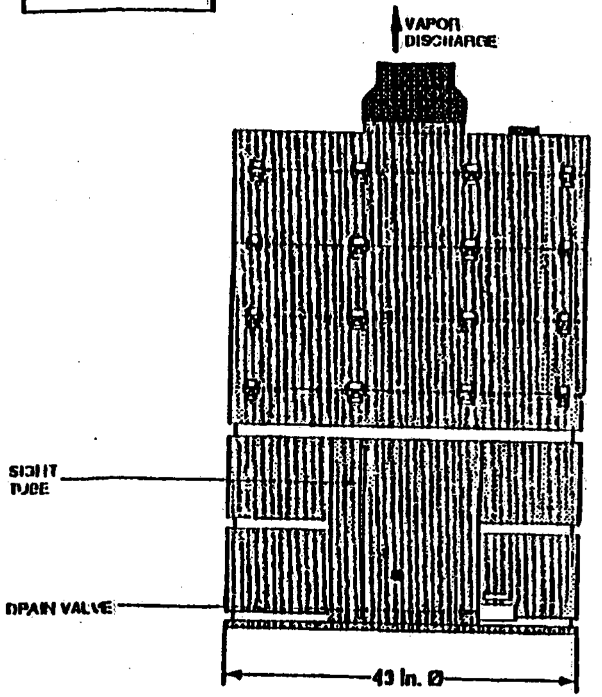
Contaminant	Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
Acetone	5 ppb 1 ppb	4 ppb 0.000005 20.8477%	4 ppb 0.000006 37.3491%	3 ppb 0.000010 50.4104%	2 ppb 0.000015 60.7487%
Methylene Chloride	15 ppb 1 ppb	1 ppb 0.000070 98.0893%	<1 ppb 0.000075 99.9635%	<1 ppb 0.000075 99.9993%	<1 ppb 0.000075 100.0000%

Due to its miscibility with water, acetone removal is difficult to predict. Call your neep representative for more in

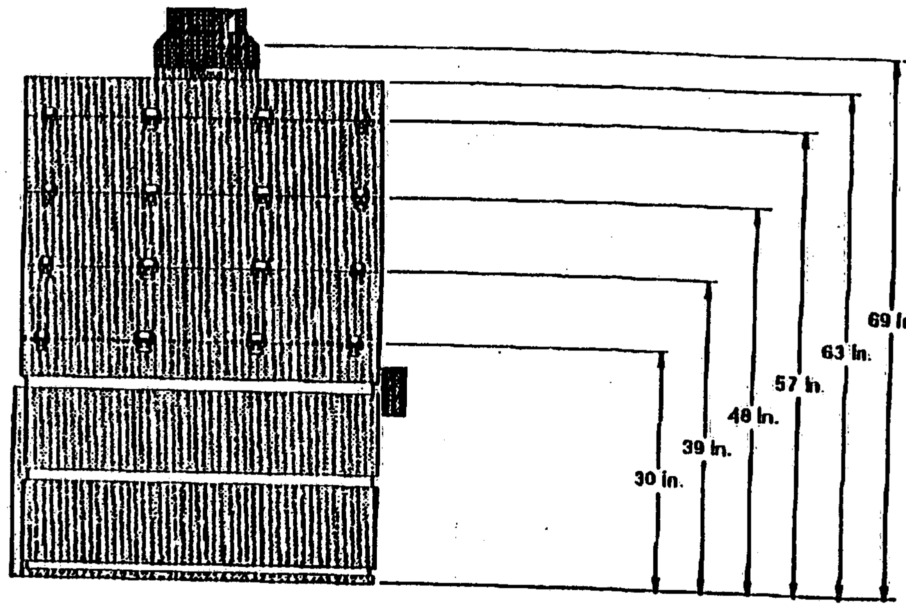
This report has been generated by ShallowTray Modeler software version 2.1W. This software is designed to assist a skilled operator in predicting the performance of a ShallowTray air stripping system. North East Environmental Products, Inc. is not responsible for incidental or consequential damages resulting from the improper operation of either the software or the air stripping equipment.
Report generated: 9/16/1998

MINIMUM CLEARANCE	
FRONT	1.5 ft.
TOP	12 in.
REAR	1.5 ft.
LEFT	2 ft.
RIGHT	2 ft.

FRONT



RIGHT SIDE



BASIC SYSTEM

- ✓ SUMP TANK
- ✓ STRIPPER TRAYS
- BLOWER
- ✓ MIST ELIMINATOR
- ✓ PIPING
- ✓ SPRAY NOZZLE
- ✓ WATER LEVEL SIGHT TUBE
- ✓ GASKETS
- ✓ LATCHES

OPTIONAL ITEMS

- ___ FRAME
- ___ AIR PRESSURE GAUGE
- ___ DISCHARGE PIPING
- ___ DISCHARGE PUMP
- ___ FEED PUMP
- ___ ADDITIONAL BLOWER
- ___ EXPLOSION-PROOF MOTOR(S)
- ___ BLOWER START/STOP PANEL
- ___ CONTROL PANEL
- ___ MAIN DISCONNECT SWITCH
- ___ I.S. COMPONENTS/REMOTE MOUNT
- ___ INTERMITTENT OPERATION
- ___ STROBE LIGHT
- ___ ALARM HORN
- ___ POWER LAPSE INDICATOR
- ___ LOW AIR PRESSURE ALARM SWITCH
- ✓ HIGH WATER LEVEL ALARM SWITCH
- ✓ DISCHARGE PUMP LEVEL SWITCH
- ___ WATER PRESSURE GAUGE(S)
- ___ DIGITAL WATER FLOW INDICATOR
- ___ AIR FLOW METER
- ___ TEMPERATURE GAUGE(S)
- ___ LINE SAMPLING PORTS
- ___ AIR BLOWER SILENCER
- ___ WASHER WAND
- ___ AUTO DIALER

NOTE:

1. THIS DRAWING IS REPRESENTATIVE OF A TYPICAL CONFIGURATION SIMILAR TO THE UNIT REQUIRED, AND IS NOT INTENDED FOR ENGINEERING DESIGN OR LAYOUT. PLEASE CONTACT YOUR NEEP REPRESENTATIVE FOR DETAILED DESIGN INFORMATION.

CONNECTION INFORMATION

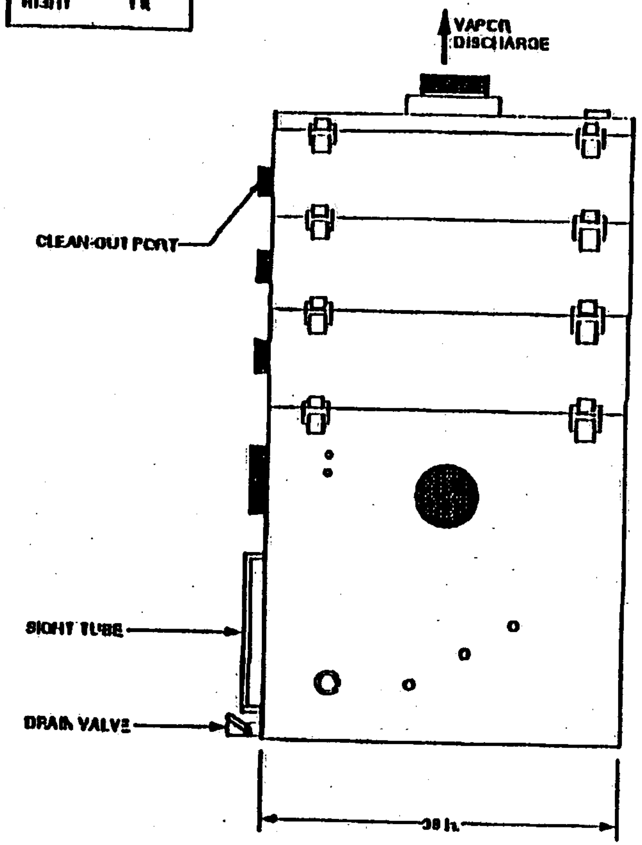
ITEM	SIZE
GRAVITY DISCHARGE	2 in. Ø SOCKET, PVC80
DISCHARGE PUMP	3/4 in. Ø FNPT
WATER INLET	1-1/4 in. Ø FNPT
AIR EXHAUST NOZZLE	8 in. Ø STUB W/8x8 CPLG

NORTH EAST ENVIRONMENTAL PRODUCTS, INC.
17 TECHNOLOGY DRIVE
WEST LEBANON, NEW HAMPSHIRE 03784
PHONE: 603-298-7061 FAX: 603-298-7063

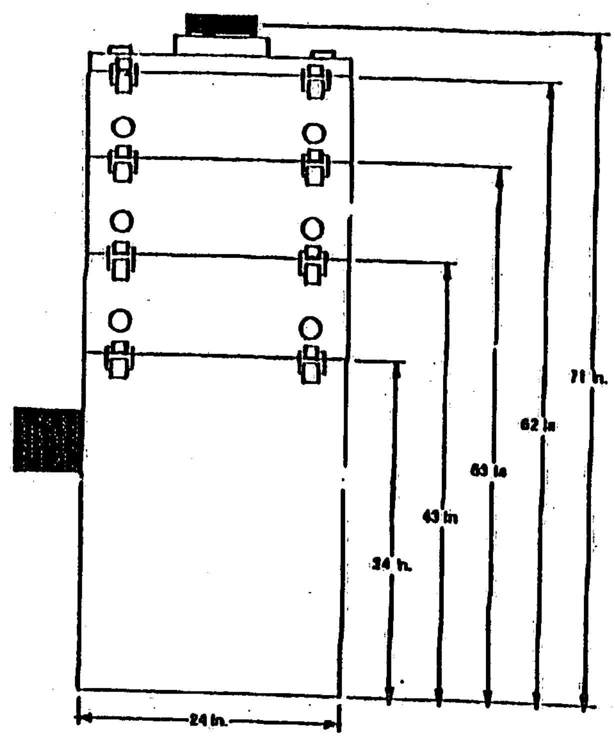
DRAWING NAME:	ShallowTray® Model 2330-P
DRAWING #:	Proposal #697906
DRAWN: DCS	CUSTOMER: Independent Equip: Forensic, USVI
DATE: 6/20/97	SCALE: NTS — SIZE: A — SHEET: 1 OF 1

MINIMUM CLEARANCE	
FRONT	1.5 ft.
TOP	12 in.
REAR	NA
LEFT	3.5 ft.
RIGHT	1 ft.

FRONT



RIGHT SIDE



BASIC SYSTEM

- ✓ SUMP TANK
- ✓ STRIPPER TRAYS
- BLOWER
- ✓ MIST ELIMINATOR
- ✓ PIPING
- ✓ SPRAY NOZZLE
- ✓ WATER LEVEL SIGHT TUBE
- ✓ GASKETS
- ✓ LATCHES

OPTIONAL ITEMS

- ___ FRAME
- ___ AIR PRESSURE GAUGE
- ___ DISCHARGE PIPING
- ___ DISCHARGE PUMP
- ___ FEED PUMP
- ___ ADDITIONAL BLOWER
- ___ EXPLOSION PROOF MOTOR(S)
- ___ BLOWER START-STOP PANEL
- ___ CONTROL PANEL
- ___ MAIN DISCONNECT SWITCH
- ___ I.S. COMPONENTS-REMOTE MOUNT
- ___ INTERMITTENT OPERATION
- ___ STROBE LIGHT
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- ___ POWER LAPSE INDICATOR
- ✓ LOW AIR PRESSURE ALARM SWITCH
- ✓ HIGH WATER LEVEL ALARM SWITCH
- ✓ DISCHARGE PUMP LEVEL SWITCH
- ___ WATER PRESSURE GAUGE(S)
- ___ DIGITAL WATER FLOW INDICATOR
- ___ AIR FLOW METER
- ___ TEMPERATURE GAUGE(S)
- ___ LINE SAMPLING PORTS
- ___ AIR BLOWER SILENCER
- ___ WASHER WAND
- ___ AUTO DIALER

NOTE:

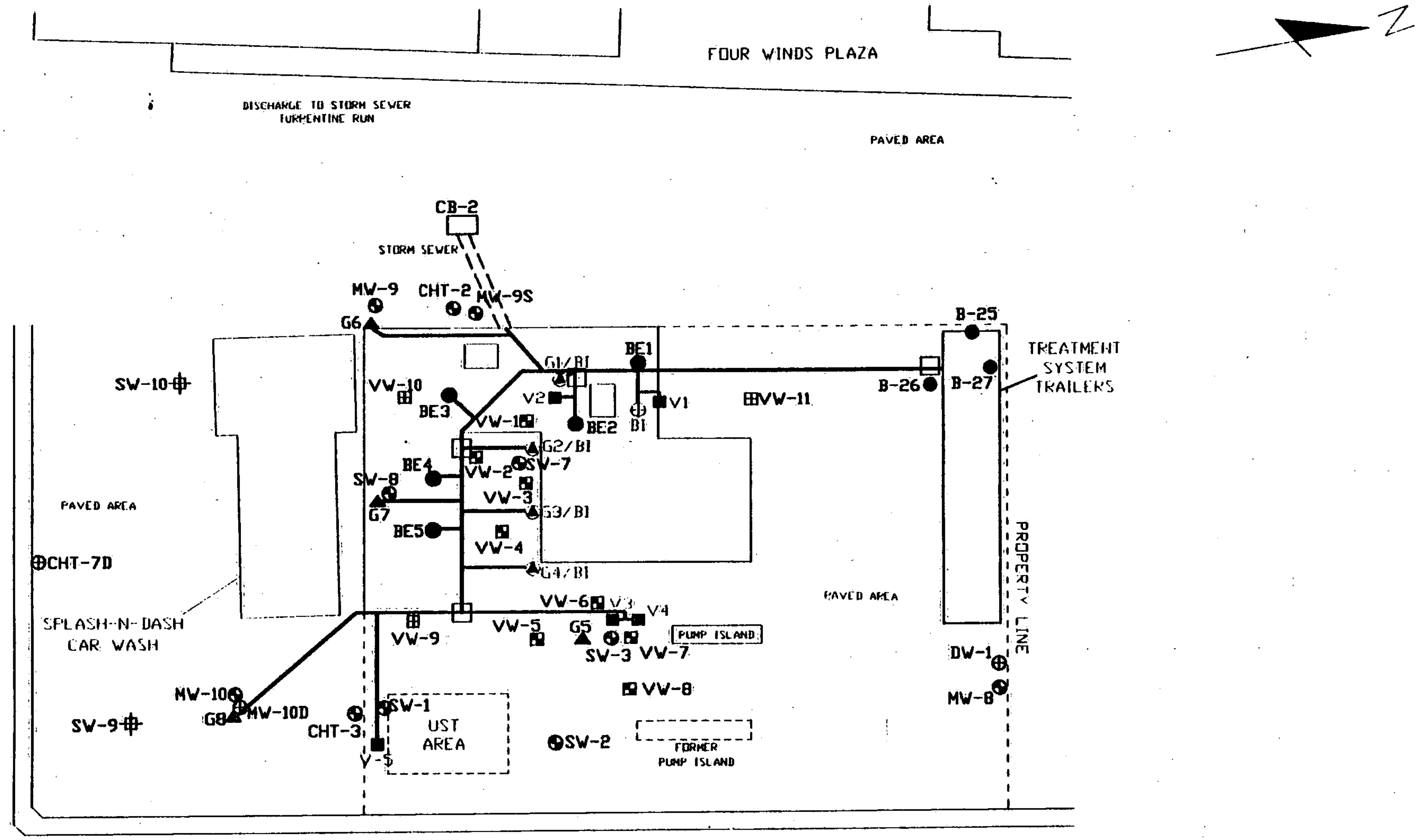
1. THIS DRAWING IS REPRESENTATIVE OF A TYPICAL CONFIGURATION SIMILAR TO THE UNIT REQUIRED, AND IS NOT INTENDED FOR ENGINEERING DESIGN OR LAYOUT. PLEASE CONTACT YOUR NEEP REPRESENTATIVE FOR DETAILED DESIGN INFORMATION

CONNECTION INFORMATION

ITEM	SIZE
GRAVITY DISCHARGE	3 in. Ø SOCKET, PVC(?)
DISCHARGE PUMP	3/4 in. Ø FNPT
WATER INLET	2 in. Ø FNPT
AIR EXHAUST NOZZLE	6 in. Ø STUB w/6 in. CPLG

NORTH EAST ENVIRONMENTAL PRODUCTS, INC.
17 TECHNOLOGY DRIVE
WEST LEBANON, NEW HAMPSHIRE 03784
PHONE: 603-298-7061 FAX: 603-298-7063

TOLERANCES UNLESS OTHERWISE SPECIFIED ± 1 inch	DRAWING NAME: ShallowTray® Model 2330
	DRAWING #: Proposal # 607906
DRAWN: SAC	CUSTOMER: Independent Equip: Forensic, USVI
DATE: 6/20/97	SCALE: NTS · SIZE: A · SHEET 1 OF 1



LEGEND

VW-8	EXISTING VAPOR MONITORING POINT	V1	VAPOR EXTRACTION WELL
VW-9	PROPOSED VAPOR MONITORING POINT	BI	BIOVENTING INJECTION WELL
SW-10	PROPSED MONITORING WELL LOCATION	BE	BIOVENTING EXTRACTION WELL
SW-1	EXISTING MONITORING WELL LOCATION	G8	GROUND-WATER EXTRACTION WELL
B-25	PROPOSED SOIL BORING LOCATION	G4/BI	GROUND-WATER EXTRACTION WELL CONVERTED TO BIOVENTING INJECTION WELL
			SYSTEM TRENCH

FORENSIC ENVIRONMENTAL SERVICES, INC.

FIGURE 1

SOIL AND GROUND-WATER REMEDIATION SYSTEM SCHEMATIC
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.

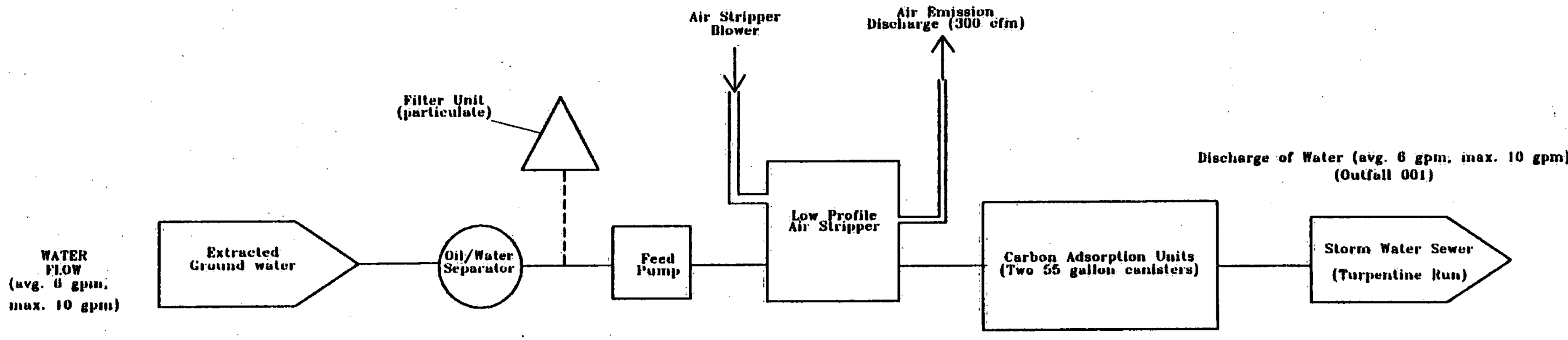
0 50
SCALE IN FEET

DRAWN BY: BJM. 8/11/98

APPROVED BY:

SOILGWPM.DWG

Esso Tutu Service Station
Air Pollution Control
Ground-Water Flow Diagram



Notes:

1. Influent water will be sourced from four ground-water extraction wells (four overburden, 4 shallow bedrock). It is anticipated that ground water will be extracted from each overburden well at an average rate of 0.5 gallons per minute (gpm), and from each shallow bedrock well at an average rate of 1.0 gpm, for a total average withdrawl of 6 gpm.
2. Discharge of vapors from the air stripper will occur at a rate of approximately 300 cubic feet per minute (cfm).
   The estimated concentration of total volatile organic compounds in the air stream is 0.078 pounds per hour at 6 gpm, and 0.130 pounds per hour at 10 gpm.

TUTULINE.DWG

GOVERNMENT OF
THE VIRGIN ISLANDS OF THE UNITED STATES
DEPARTMENT OF PLANNING AND NATURAL RESOURCES
AIR POLLUTION CONTROL

APPLICATION

AUTHORITY TO CONSTRUCT AND PERMIT TO OPERATE

INSTRUCTIONS

A. This application must be filled out completely and must be filed in TRIPLICATE.

B. Applications are incomplete unless accompanied by DUPLICATE copies of all plans, specifications and drawings required. Details required for specific equipment are listed on separate forms which are available upon request.

INCOMPLETE APPLICATIONS ARE NOT ACCEPTABLE

REVISED
Date of Application: SEPT. 24, 1998

APPLICATION INFORMATION

1. Permit to be issued to: (Business License Name of Corporation, Company, Individual Owner or Governmental Agency that is to operate the Equipment):

ESSO VIRGIN ISLANDS, INC

2. Mailing Address:
P.O. Box ESSO TERMINAL City CHARLOTTE AMALIE Island ST. THOMAS Zip 00801

3. Address at which the equipment is to be operated:
Number 384 Street ESTATE ANNA'S RETREAT Island ST. THOMAS Zip 00802

4. Type of Organization: Corp. X Partnership ______ Individual Owner ______ Governmental Agency ______

5. General Nature of Business:

PETROLEUM RETAIL SERVICE STATION

6. Equipment Description: Pursuant to the Provisions of the U.S. Virgin Islands Code and the Rules and Regulations of the Air Pollution Control Region, application is hereby made for authority to construct and permit to operate the following equipment:

SOIL VAPOR EXTRACTION SYSTEM (ESSO TUTU SOIL REMEDIATION PROGRAM)

Sec. A	1. ☒ New process equipment and new air pollution control apparatus ☐ New air pollution control apparatus on existing process equipment ☐ New process equipment with no control apparatus ☐ Other: ______ 2. Prior permit numbers covering this installation. Specify. NOT APPLICABLE 3. Estimated starting date OCTOBER 1998 Est. completion 2002
Sec. B	1. Description of operation REMOVAL OF CONTAMINANTS FROM SUBSURFACE BY VACUUM EXTRACTION 2. Identify process equipment VACUUM BLOWER, CATALYTIC OXIDIZER 3. Raw materials (names) VAPORS FROM SOIL CONTAMINATED WITH PETROLEUM CONSTITUENTS AND CHLORINATED HYDROCARBONS Total pounds per hour 0.043 Total pounds per batch — SEE ATTACHED TABLES (1a AND 1b) 4. Operating procedure: ☒ Continuous: 24 hrs. per day 7 days per ☒ week ☐ month ☐ Batch: — hrs. per batch — batches per ☐ day ☐ week
	Physical and chemical nature of air contaminants which must evolve from operation and be emitted into the open air:

Sec. C

Air Contaminants	Amounts of Contaminants: With Control Apparatus	Amounts of Contaminants: Without Control Apparatus
(SEE ATTACHED TABLE 1C		
FOR A COMPLETE LIST OF		
AIR CONTAMINANTS)		

Sec. D

1. Describe air pollution control apparatus EXTRACTED SOIL VAPORS WILL BE PROCESSED THROUGH A MOISTURE KNOCK-OUT CANISTER AN IN-LINE PARTICULATE FILTER, AND A CATALYTIC OXIDATION UNIT
2. Efficiency of control apparatus: MINIMUM 95 %
3. Height of discharge above ground 9.5 ft.
4. Distance from discharge to nearest property line APPROX. 15 ft.
5. Volume of gas discharged into open air AVG. - 125 MAX. - 175 cu. ft. per min. at stack conditions.
6. Exit linear velocity at point of discharge 560 ft. per min. at stack conditions.
7. Temperature at point of discharge 600 °F.
8. Will emissions comply with existing local requirements? YES
9. Initial cost of control apparatus $ N/A
10. Estimated annual operating cost $ 40,000

This application is submitted in accordance with the provisions of the Virgin Islands Code 12, Chapter 9, Air Quality Control Regulations Section 206-20, and to the best of my knowledge and belief is true and correct.

ESSO VIRGIN ISLANDS INC	
CYRIL E. KING	Signature - all copies
AIRPORT TERMINAL	Name (print or type)
ST. THOMAS USVI	
Mailing Address	Title
00804	
Zip Code	Telephone No.

AUTHORITY TO CONSTRUCT AND PERMIT TO OPERATE

Date: Approved by:

Permit No. Supervisor, Permits & Certification

Esso Tutu Service Station
SVE System
Air Pollution Control Permit
Equipment Description

System Description

As part of the USEPA CERCLA Record of Decision, Esso Virgin Islands, Inc. is required to remediate subsurface soils beneath the Esso Tutu Service Station. The subject site is located on Route 38, Anna's Retreat, St. Thomas, adjacent to Four Winds Plaza (Figure 1).

The proposed soil remedial program will involve the extraction of soil vapors from five vapor extraction wells and five bioventing wells (Figure 1). Wells will be installed to a depth of approximately 15 feet and utilized to extract gases within the soil matrix at a flow rate of 15 to 20 cubic feet per minute (cfm) per vapor extraction well. Bioventing wells will be utilized to extract vapors at 3 to 5 cfm. Extracted soil vapors will be transferred to an on-site treatment building through two manifold systems (SVE and bioventing), as shown in Figure 1. The process flow of the extracted vapors in the treatment building will include the following components:

1. Moisture knockout tank,
2. Filter apparatus (particulate),
3. Vacuum blower, and
4. Catalytic oxidizer (Cat-ox)

The above components will operate in conjunction as the Control Apparatus for the soil vapor extraction remedial system. The treatment system has been designed to reduce contaminant concentrations in the vapor effluent to 0.0428 lbs/hour (see Tables 1a, 1b, and 1c). Treated soil vapors will be discharged to the atmosphere via the insulated cat-ox stack. The above components are illustrated in attached "Soil Vapor Flow Diagram" and "Process & Instrumentation Diagram".

Equipment Description

Air emissions associated with the soil vapor remediation system will occur only after treatment by catalytic oxidation. All components upstream of the cat-ox unit are air-tight and will not produce any emissions. The selected vacuum blower is a Rotron-brand, Model EN/CP6 Regenerative Blower, capable of generating an air flow rate of 175 cfm at 20 inches of water column. The cat-ox unit (ThermTech Model #VAC-25) is capable of processing air flows up to 225 cfm.

Off-gas concentrations will be monitored during operation of the remedial system to ensure that effluent concentrations do not exceed those predicted. Compliance monitoring will include both vapor measurements using a Photoionization Detector (PID) and the collection of vapor samples for analytical testing. A schedule for compliance monitoring for the first 12 months is provided on Table 1d. DPNR will be copied on all air emission monitoring data.

The mass of VOC compounds removed by the SVE system are expected to decrease over time and eventually level off. It is anticipated that DPNR will establish a de minimus cut-off value for the influent monitoring, at which, the SVE treatment system will no longer require control apparatus. At this point, untreated effluent from the SVE/Bioventing system would be discharged directly to the atmosphere, with de minimus quantities of VOCs released.

Table 1a
Air Emissions Calculations (Average System Discharge)
SVE System (Catalytic Oxidizer Effluent)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Compound	Average Soil Vapor Concentration		Molecular Weight	Average Contaminant Mass Per Well				Contaminant Mass All Wells @ 125 cfm		Contaminant Mass All Wells @ 175 cfm	
	ppbv	ppmv	gm/mole	mg/m^3	kg/m^3	kg/ft^3	lbs/ft^3	lbs/cfm	$lbs/ft^3/hour$	lbs/cfm	$lbs/ft^3/hour$
Pentane	123200	123.200	72.2	363.805	3.64E-04	1.03E-05	2.27E-05	0.0028	0.170	0.0040	0.239
Hexane	9300	9.300	86.2	32.788	3.28E-05	9.29E-07	2.05E-06	0.0003	0.015	0.0004	0.021
Heptane	74	0.074	100.2	0.303	3.03E-07	8.59E-09	1.89E-08	2.37E-06	1.42E-04	3.31E-06	1.99E-04
Isooctane	4530	4.530	114.2	21.159	2.12E-05	5.99E-07	1.32E-06	0.0002	0.010	0.0002	0.014
Octane	434	0.434	114.2	2.027	2.03E-06	5.74E-08	1.27E-07	1.58E-05	0.001	2.21E-05	0.001
Benzene	1910	1.910	78.1	6.101	6.10E-06	1.73E-07	3.81E-07	4.76E-05	0.003	6.67E-05	0.004
MTBE	7	0.007	88.2	0.025	2.52E-08	7.15E-10	1.58E-09	1.97E-07	1.18E-05	2.76E-07	1.65E-05
Toluene	316	0.316	92.1	1.190	1.19E-06	3.37E-08	7.43E-08	9.29E-06	0.001	1.30E-05	0.001
Ethylbenzene	4026	4.026	106.2	17.487	1.75E-05	4.95E-07	1.09E-06	0.0001	0.008	0.0002	0.011
m- & p- Xylenes	372	0.372	106.2	1.616	1.62E-06	4.58E-08	1.01E-07	1.26E-05	0.001	1.77E-05	0.001
o-Xylenes	104	0.104	106.2	0.452	4.52E-07	1.28E-08	2.82E-08	3.53E-06	2.12E-04	4.94E-06	2.96E-04
4-Ethyltoluene	256	0.256	120.2	1.259	1.26E-06	3.56E-08	7.86E-08	9.82E-06	0.001	1.38E-05	0.001
Cumene	1453	1.453	120.2	7.143	7.14E-06	2.02E-07	4.46E-07	0.0001	0.003	7.80E-05	0.005
1,2,4 Trimethylbenzene	406	0.406	120.2	1.996	2.00E-06	5.65E-08	1.25E-07	1.56E-05	9.35E-04	2.18E-05	1.31E-03
1,3,5 Trimethylbenzene	142	0.142	120.2	0.698	6.98E-07	1.98E-08	4.36E-08	5.45E-06	3.27E-04	7.63E-06	4.58E-04
Carbon Disulfide	19	0.019	76.1	0.059	5.91E-08	1.67E-09	3.69E-09	4.62E-07	2.77E-05	6.46E-07	3.88E-05
Freon 113	19	0.019	187.4	0.146	1.46E-07	4.12E-09	9.09E-09	1.14E-06	6.82E-05	1.59E-06	9.55E-05
Trichloroethene	18	0.018	131.4	0.097	9.67E-08	2.74E-09	6.04E-09	7.55E-07	4.53E-05	1.06E-06	6.34E-05
Tetrachloroethane	101	0.101	165.8	0.685	6.85E-07	1.94E-08	4.28E-08	5.35E-06	3.21E-04	7.48E-06	4.49E-04
TICs/C_3-C_4	12107	12.107	86.2	42.684	4.27E-05	1.21E-06	2.67E-06	0.0003	0.020	0.0005	0.028
TICs/C_5-C_{10}	9990	9.990	184.4	75.344	7.53E-05	2.13E-06	4.70E-06	5.88E-04	0.035	0.0008	0.049
	A	B = A/1000	C	D = BxC/24.45	E = D/1000000	F = E/35.31	G = Fx2.20	H = Gx125	I = Hx60	H = Gx125	I = Hx60
Total vapor contaminant mass removed by treatment system in pounds/hour =									0.270		0.378
Total estimated air emission in pounds/hour (assumes minimum cat-ox destruction efficiency of 95%) =									**0.014**		**0.019**

ppbv = parts per billion by volume, ppmv = parts per million by volume, mg = milligrams, gm = grams,
kg = kilograms, lbs = pounds, m^3 = cubic meters, ft^3 = cubic feet, cfm = cubic feet per minute
TICs = tentatively identified compounds. For estimation purposes, the TIC with the highest molecular weight in each group (2,2-dimethylbutane, 2,3,4,-trimethyldecane) was used in the calculations.
Average soil vapor concentrations based on quantitative vapor samples collected at the site in September/October 1996.
Total estimated air flow from all wells is estimated at 125 cfm. Catalytic oxidizer will provide at least 95% treatment efficiency.

Table 1b
Air Emissions Calculations (Maximum System Discharge)
SVE System (Catalytic Oxidizer Effluent)
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Compound	Maximum Soil Vapor Concentration		Molecular Weight	Average Contaminant Mass Per Well				Contaminant Mass All Wells @ 125 cfm		Contaminant Mass All Wells @ 175 cfm	
	ppbv	ppmv	gm/mole	mg/m^3	kg/m^3	kg/ft^3	lbs/ft^3	lbs/cfm	$lbs/ft^3/hour$	lbs/cfm	$lbs/ft^3/hour$
Pentane	260000	260.000	72.2	767.771	7.68E-04	2.17E-05	4.79E-05	0.0060	0.360	0.0084	0.503
Hexane	19000	19.000	86.2	66.986	6.70E-05	1.90E-06	4.18E-06	0.0005	0.031	0.0007	0.044
Heptane	200	0.200	100.2	0.820	8.20E-07	2.32E-08	5.12E-08	6.40E-06	3.84E-04	8.96E-06	5.37E-04
Isooctane	9200	9.200	114.2	42.971	4.30E-05	1.22E-06	2.68E-06	0.0003	0.020	0.0005	0.028
Octane	1300	1.300	114.2	6.072	6.07E-06	1.72E-07	3.79E-07	4.74E-05	0.003	0.0001	0.004
Benzene	5500	5.500	78.1	17.569	1.76E-05	4.98E-07	1.10E-06	0.0001	0.008	0.0002	0.012
MTBE	20	0.020	88.2	0.072	7.21E-08	2.04E-09	4.50E-09	5.63E-07	3.38E-05	7.88E-07	4.73E-05
Toluene	920	0.920	92.1	3.466	3.47E-06	9.81E-08	2.16E-07	2.70E-05	0.002	3.79E-05	0.002
Ethylbenzene	12000	12.000	106.2	52.123	5.21E-05	1.48E-06	3.25E-06	0.0004	0.024	0.0006	0.034
m- & p- Xylenes	1100	1.100	106.2	4.778	4.78E-06	1.35E-07	2.98E-07	3.73E-05	0.002	0.0001	0.003
o-Xylenes	300	0.300	106.2	1.303	1.30E-06	3.69E-08	8.14E-08	1.02E-05	6.10E-04	1.42E-05	8.54E-04
4-Ethyltoluene	760	0.760	120.2	3.736	3.74E-06	1.06E-07	2.33E-07	2.92E-05	0.002	4.08E-05	0.002
Cumene	4300	4.300	120.2	21.139	2.11E-05	5.99E-07	1.32E-06	0.0002	0.010	0.0002	0.014
1,2,4 Trimethylbenzene	1200	1.200	120.2	5.899	5.90E-06	1.67E-07	3.68E-07	4.60E-05	0.003	0.0001	0.004
1,3,5 Trimethylbenzene	420	0.420	120.2	2.065	2.06E-06	5.85E-08	1.29E-07	1.61E-05	9.67E-04	2.26E-05	0.001
Carbon Disulfide	50	0.050	76.1	0.156	1.56E-07	4.41E-09	9.72E-09	1.21E-06	7.29E-05	1.70E-06	1.02E-04
Freon 113	50	0.050	187.4	0.383	3.83E-07	1.09E-08	2.39E-08	2.99E-06	1.79E-04	4.19E-06	2.51E-04
Trichloroethene	29	0.029	131.4	0.156	1.56E-07	4.41E-09	9.73E-09	1.22E-06	7.30E-05	1.70E-06	1.02E-04
Tetrachloroethane	230	0.230	165.8	1.560	1.56E-06	4.42E-08	9.74E-08	1.22E-05	7.30E-04	1.70E-05	0.001
TICs/C_3-C_4	31500	31.500	86.2	111.055	1.11E-04	3.15E-06	6.93E-06	0.0009	0.052	0.0012	0.073
TICs/C_5-C_{10}	26000	26.000	184.4	196.090	1.96E-04	5.55E-06	1.22E-05	0.0015	0.092	2.14E-03	0.129
	A	B = A/1000	C	D = BxC/24.45	E = D/1000000	F = E/35.31	G = Fx2.20	H = Gx125	I = Hx60	H = Gx125	I = Hx60
Total vapor contaminant mass removed by treatment system in pounds/hour =									0.612		0.856
Total estimated air emission in pounds/hour (assumes minimum cat-ox destruction efficiency of 95%) =									**0.031**		**0.043**

ppbv = parts per billion by volume, ppmv = parts per million by volume, mg = milligrams, gm = grams,
kg = kilograms, lbs = pounds, m^3 = cubic meters, ft^3 = cubic feet, cfm = cubic feet per minute
TICs = tentatively identified compounds. For estimation purposes, the TIC with the highest molecular weight in each group (2,2-dimethylbutane, 2,3,4,-trimethyldecane) was used in the calculations.
Maximum soil vapor concentrations based on quantitative vapor samples collected at the site in September/October 1996.
Total estimated air flow from all wells is estimated at 125 cfm. Catalytic oxidizer will provide at least 95% treatment efficiency.

Table 1c
Air Emissions Calculations
SVE/Bioventing System
Esso Tutu Service Station
St. Thomas, U.S.V.I.

SECTION C				
Air Contaminants	**Amounts of Contaminants**			
	Without Control Apparatus (lbs/hr)		**With Control Apparatus (lbs/hr)**	
	125 cfm	**175 cfm**	**125 cfm**	**175 cfm**
Pentane	0.3595	0.5033	0.0180	0.0252
Hexane	0.0314	0.0439	0.0016	0.0022
Heptane	0.0004	0.0005	1.92E-05	2.69E-05
Isooctane	0.0201	0.0282	0.0010	0.0014
Octane	0.0028	0.0040	0.0001	0.0002
Benzene	0.0082	0.0115	0.0004	0.0006
MTBE	3.38E-05	4.73E-05	1.69E-06	2.36E-06
Toluene	0.0016	0.0023	0.0001	0.0001
Ethylbenzene	0.0244	0.0342	0.0012	0.0017
m- & p- Xylenes	0.0022	0.0031	0.0001	0.0002
o-Xylenes	0.0006	0.0009	3.05E-05	4.27E-05
4-Ethyltoluene	0.0017	0.0024	0.0001	0.0001
Cumene	0.0099	0.0139	0.0005	0.0007
1,2,4 Trimethylbenzene	0.0028	0.0039	0.0001	0.0002
1,3,5 Trimethylbenzene	0.0010	0.0014	0.0000	0.0001
Carbon Disulfide	0.0001	0.0001	3.64E-06	5.10E-06
Freon 113	0.0002	0.0003	8.97E-06	1.26E-05
Trichloroethene	0.0001	0.0001	3.65E-06	5.11E-06
Tetrachloroethane	0.0007	0.0010	3.65E-05	0.0001
TICs/C_3-C_4	0.0520	0.0728	0.0026	0.0036
TICs/C_5-C_{10}	0.0918	0.1286	0.0046	0.0064
TOTAL	0.6116	0.8563	0.0306	0.0428

Assumptions used to estimate discharge in pounds per hour (lbs/hr)
are identified in Table 1b (maximum concentrations).
Average operational system flow rate is estimated at 125 cubic feet per minute (cfm);
maximum estimated system flow rate is 175 cfm

Table 1d
Schedule of Compliance Monitoring
SVE System (Catalytic Oxidizer Effluent)
Air Pollution Control Permit
Esso Tutu Service Station
St. Thomas, U.S.V.I.

	Sampling Frequency	
Time From System Start-up	**Qualitative Sampling (PID)**	**Quantitative Sampling (Laboratory)**
0 - 2 weeks	Four times per week; influent and effluent	Twice per week; influent and effluent for VOCs via TO-14
2 weeks - 8 weeks	Twice per week; influent and effluent	Twice per month; influent and effluent for VOCs via TO-14
2 - 6 months	Once per week; influent and effluent	Monthly; influent and effluent for VOCs via TO-14
6 - 12 months	Once per month; influent and effluent	Monthly; influent and effluent for VOCs via TO-14

influent = pre-catalytic oxidizer vapor sample; effluent = catalytic oxidizer vapor discharge sample

February 1, 1994

VAPOR CHECK

MODEL: VAC 25

GENERAL DATA

* SCFM rating	250 SCFM (7.1 m³/min)
* burners maximum output capability	1,000,000 BTU/Hr
* burner turndown ratio	20 to 1
* combustion blower motor size	1 HP (0.75 KW)
* combustion chamber I D	27" x 27" x 60" (68.6cm x 68.6cm x 152.4cm)
* stack I D	12" x 12" (30.5cm x 30.5cm)
* skid size.	38" x 123" (99cm x 304.8cm)
* velocity through 4" process inlet	
@ 125 SCFM (3.5 m³/min) from process stream	23.8 ft/sec (7.25 m/sec)
@ 250 SCFM (7.1 m³/min) from process stream	47.5 ft/sec (14.48 m/sec)

THERMAL DATA

* SCFM added by combustion blower when fired on ratio	95 SCFM (2.7 m³/min)
* total ACFM @ 1400°F (760°C)	1219 ACFM (34.5 m³/min)
* burner chamber volume required for 0.5 seconds retention time @ 1400°F (760°C)	10.2 ft³ (0.289 m³)
* burner chamber volume required for 1.0 seconds retention time @ 1500°F (815°C)	21.4 ft³ (0.606 m³)
* stack velocity @ 1400°F (760°C)	
@ 125 SCFM (3.5 m³/min) from process stream	10.2 ft/sec (3.11 m/sec)
@ 250 SCFM (7.1 m³/min) from process stream	20.3 ft/sec (6.19 m/sec)
* estimated weight, thermal unit only	2050 lbs (703 Kg)

CATALYTIC DATA

* SCFM added by combustion blower when fired on ratio	29 SCFM (0.82 m³/min)
* total ACFM @ 600°F (315°C)	560 ACFM (15.8 m³/min)
* catalyst volume for 95% plus destructive efficiency	0.54 ft³ (15,291 cm³)
* inlet temperature	600°F (315°C)
* maximum concentrations	25% of the LEL
* stack velocity @ 600°F (315°C)	
@ 125 SCFM (3.5 m³/min) from process stream	4.7 ft/sec (1.43 m/sec)
@ 250 SCFM (7.1 m³/min) from process stream	9.3 ft/sec (2.84 m/sec)
* estimated weight, thermal unit plus catalytic module (95% destruction)	2175 (803 Kg)

* The above data is intended to be used as general, guide line type information. For specific application proposal, please contact the manufacturer.

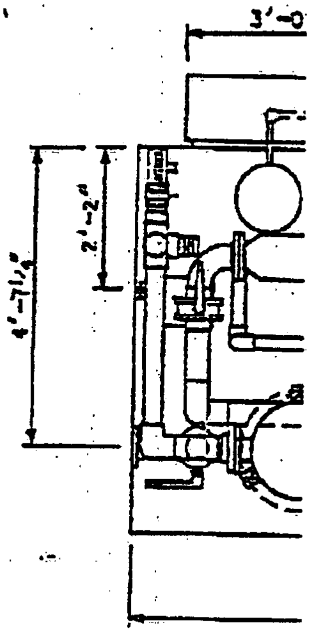
SPECIFICATIONS:

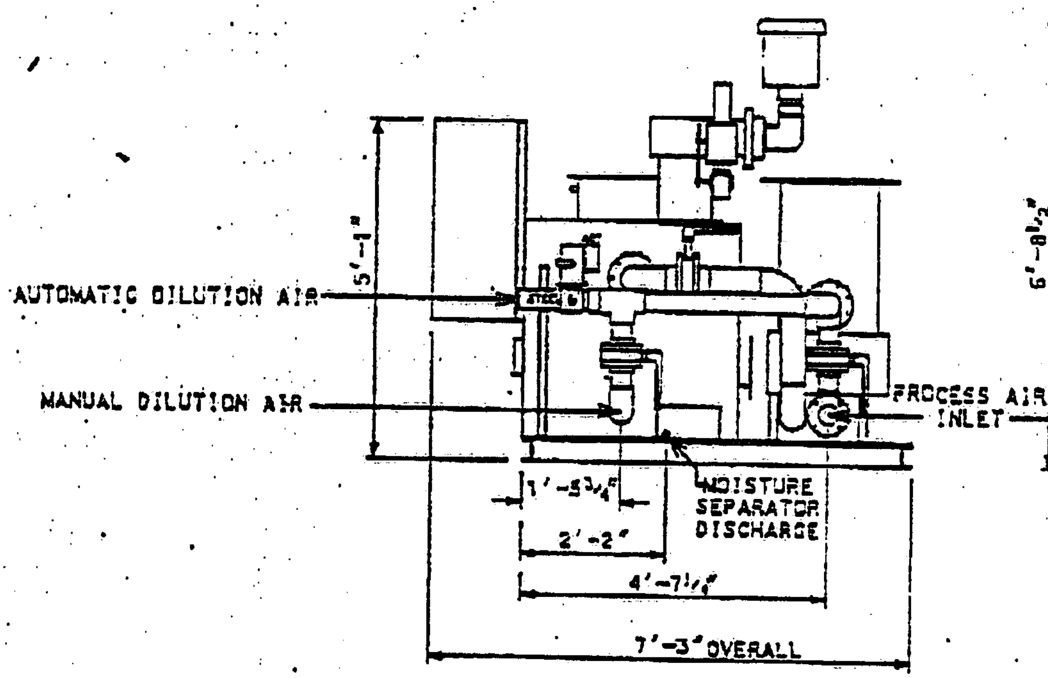
POWER: 240V/1Ø/60Hz/110 AMPS.

PURCHASED FUEL: GAS 1" N.P.T. INLET
0.6 mmBTU/HR @ 5P.S.I.G.

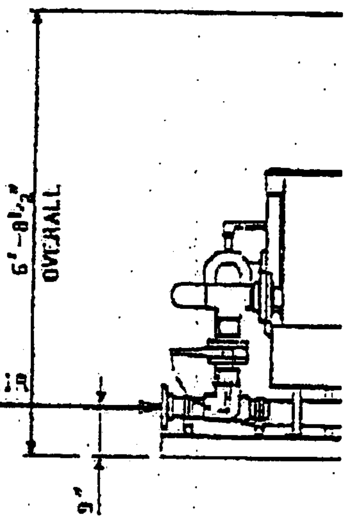
PROCESS AIR: 3" ANSI 150# FLANGE

MOISTURE SEPARATOR DISCHARGE: ½" N.P.T.



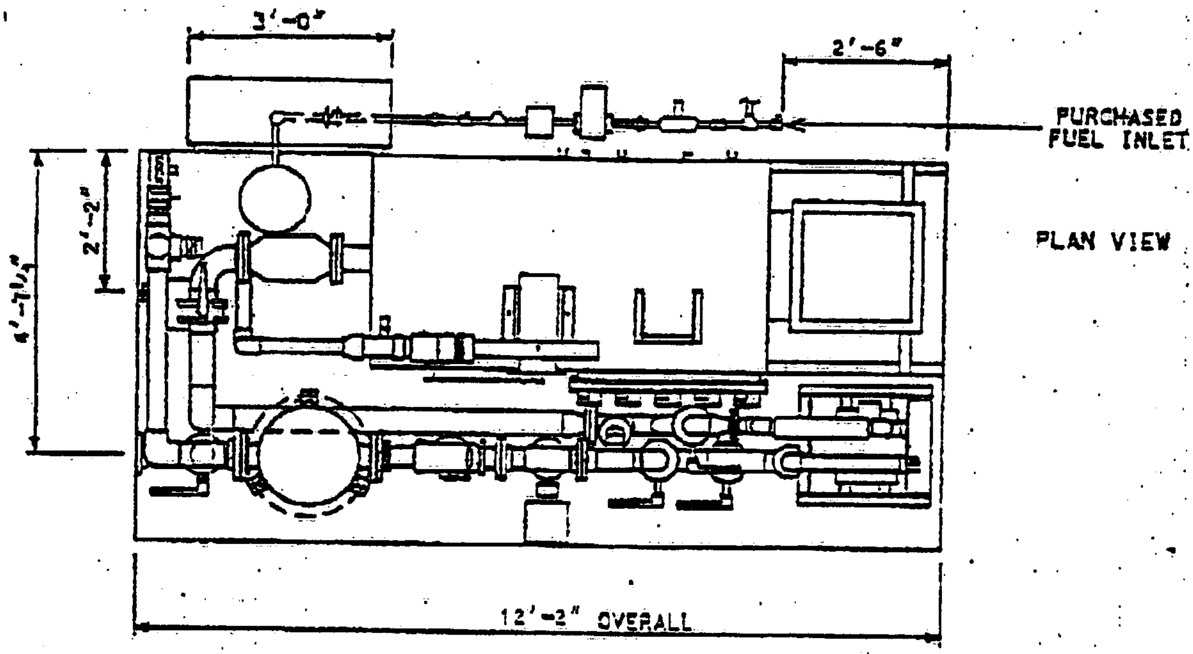


BURNER END VIEW

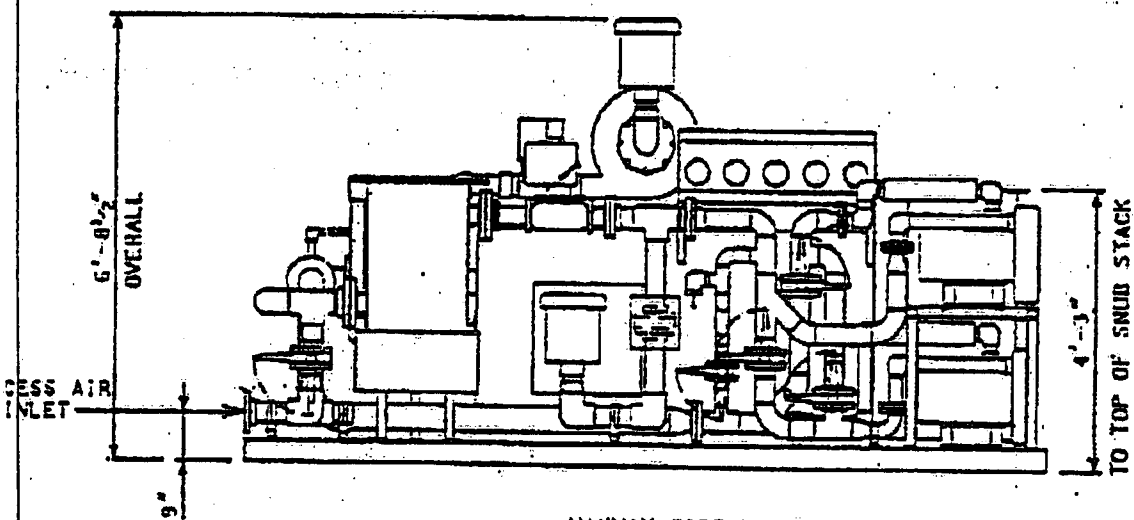


SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

NO.	DATE	REV



PLAN VIEW



MANWAY SIDE VIEW

THERMTECH, INC.
THERMAL/CATALYTIC OXIDIZERS
KINGWOOD, TEXAS 1-800-659-8271

VAC 25 SKID MOUNTED

DRAWN	L2	DATE 3/18/94	SCALE N.T.S.	JOB N/A	PAGE 1 OF 1
CH'K'D		DATE			
APP'D		DATE			

CATALYTIC

The **VAPOR CHECK** catalytic module when added to your **VAPOR CHECK** thermal oxidizer converts your thermal oxidizer to a catalytic oxidizer. This system has been designed to be as energy efficient as possible while still offering the destructive efficiency necessary to meet and/or exceed EPA and your local air quality control standards.

While the catalytic mode of operation has the distinct advantage of using less fuel than it's thermal sister it also has some inherent disadvantages. Catalyst of all types, can be deactivated by lead, sulfur, chlorinated hydrocarbons, silicon and phosphorus containing compounds. The result of this deactivation is reduction of destructive efficiency. In addition to those compounds mentioned, all particulates may also cover catalyst surfaces, thereby reducing activity by this masking effect. While trace amounts of the above agents may not lower the catalyst activity or shorten it's life, appreciable quantities must not be present in the gas stream. Check with Factory for written recommendations specifically addressing your process stream.

Our catalyst is an extremely active precious metal catalyst having a lower temperature limit of 500°F (260°C) and an upper temperature limit of 1350°F (732°C). Generally, in a field catalytic oxidizer such as the **VAPOR CHECK** system, you will find a 25°F (13.8°C) increase in the catalyst bed temperature for each 1.0% of the LEL of hydrocarbon passing through the bed. For specific application information, please supply us with the exact chemical analysis.

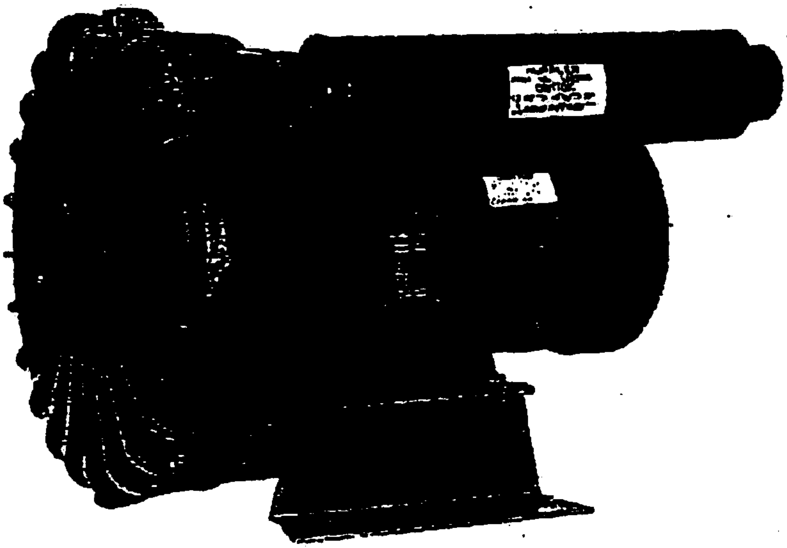
The destructive efficiency of your catalytic system is directly related to the catalytic bed temperature, the quantity of catalyst in the bed, and the actual condition of the catalyst. Typically, the destructive efficiency of this catalytic system can be improved by increasing either/or both the amount of catalyst and /or the bed's inlet temperature while observing the exit temperature to be sure you do not exceed the catalyst's upper temperature limit of operation. This is an important fact about the operation of a catalytic oxidizer. If the catalyst is in good condition (has not been deactivated), the difference between 50% destructive efficiency and 99% destructive efficiency is directly related to the amount of catalyst in the bed and the temperature of that bed.

EN/CP 6
Explosion-Proof Regenerative Blower

EN FEATURES
- Manufactured in the USA
- Maximum flow: 225 SCFM
- Maximum pressure: 104" WG
- Maximum vacuum: 85" WG
- Standard motor: 5.0 HP
- Blower construction – cast aluminum housing, cover, impeller & manifold; cast iron flanges
- UL & CSA approved motors for Class I, Group D atmospheres
- Sealed blower assembly
- Quiet operation within OSHA standards

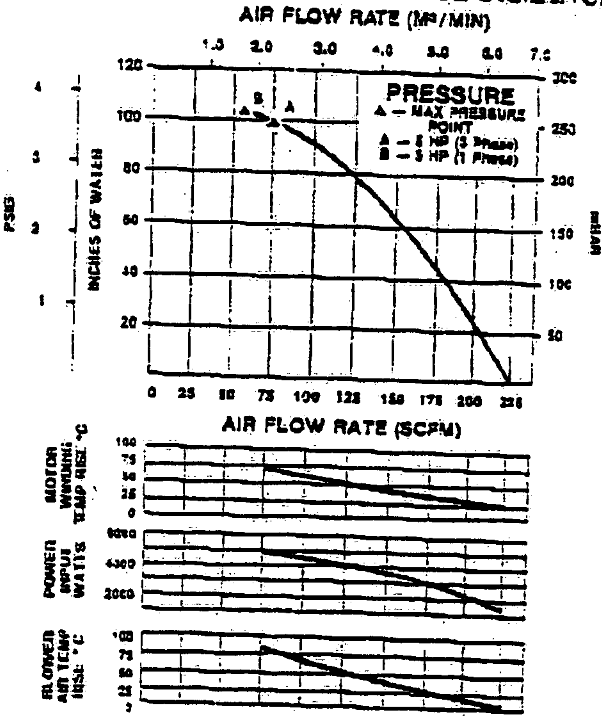
OPTIONS
- TEFC motors
- 50 Hz motors
- International voltages
- Other HP motors
- Corrosion resistant surface treatments
- Remote drive (motorless) models

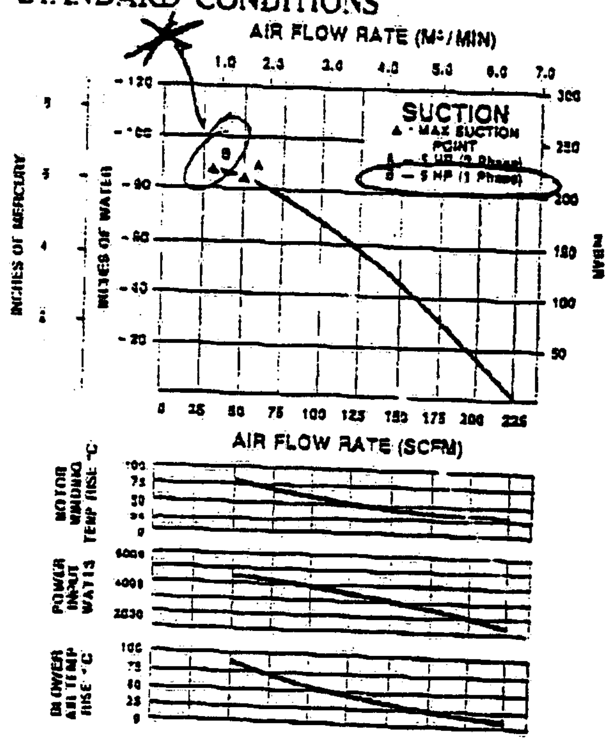
ACCESSORIES
- Moisture separators
- Explosion-proof motor starters
- Inline & inlet filters
- Vacuum & pressure gauges
- Relief valves
- External mufflers



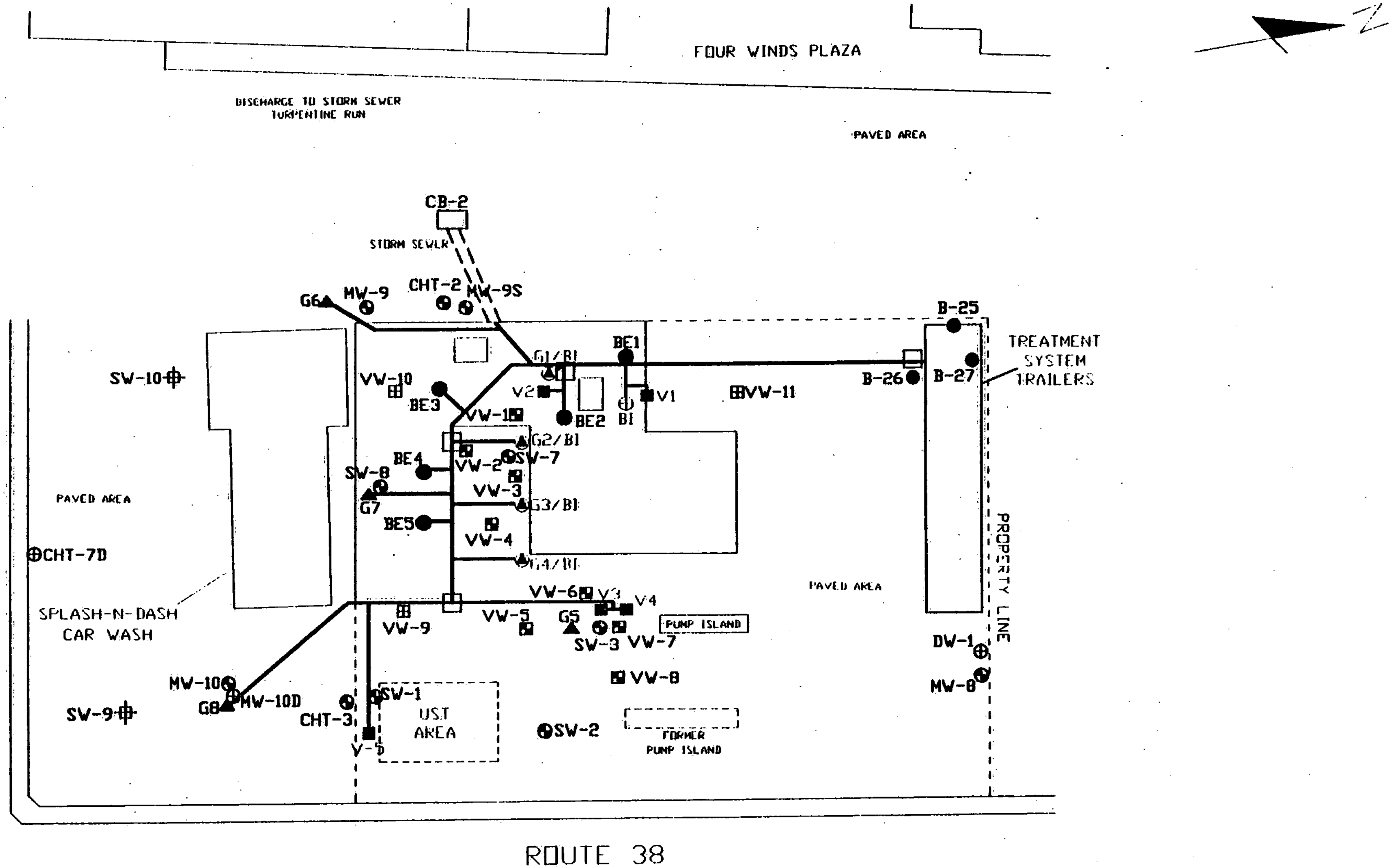
Blowers on Exxon Skid w/ oxidizer

BLOWER PERFORMANCE AT STANDARD CONDITIONS





EG&G ROTRON, SAUGERTIES N.Y. 12477 • 914/246-3401 • FAX 914/246-3802



LEGEND

VW-8 EXISTING VAPOR MONITORING POINT	V VAPOR EXTRACTION WELL
VW-9 PROPOSED VAPOR MONITORING POINT	BI BIOVENTING INJECTION WELL
SW-10 PROPSED MONITORING WELL LOCATION	BE BIOVENTING EXTRACTION WELL
SW-1 EXISTING MONITORING WELL LOCATION	G8 GROUND WATER EXTRACTION WELL
B-25 PROPOSED SOIL BORING LOCATION	G4/BI GROUND-WATER EXTRACTION WELL CONVERTED TO BIOVENTING INJECTION WELL
	SYSTEM TRENCH

FORENSIC ENVIRONMENTAL SERVICES, INC.

FIGURE 1

SOIL AND GROUND-WATER REMEDIATION SYSTEM SCHEMATIC

ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.

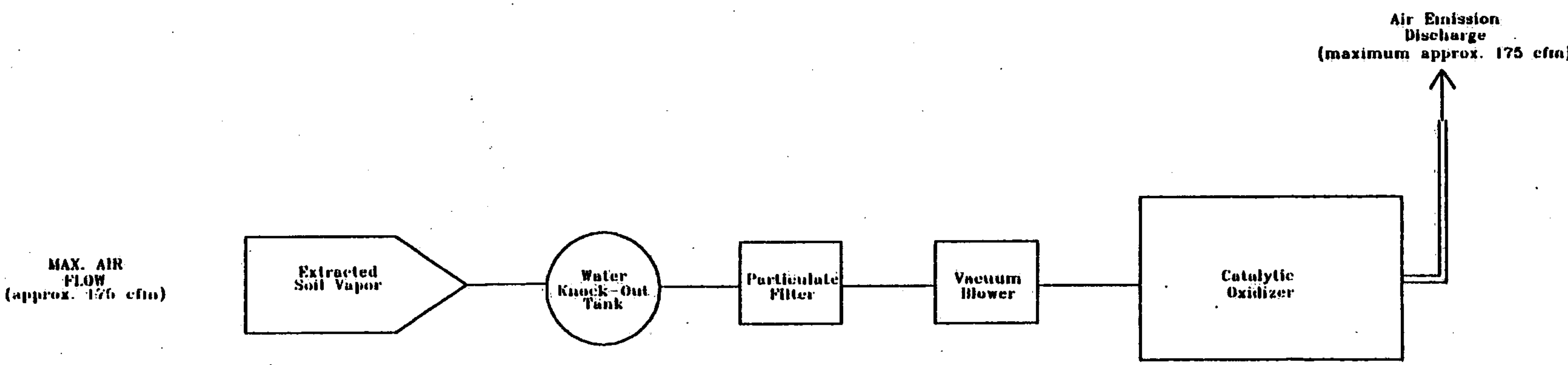
0 50
SCALE IN FEET

DRAWN BY: BJH 8/11/98

APPROVED BY:

SOILGWPM.DWG

Esso Tutu Service Station
Air Pollution Control
Soil Vapor Flow Diagram



Notes:

1. Influent soil vapors will be sourced from five soil vapor extraction wells and five bioventing wells. It is anticipated that soil vapors will be extracted from vapor extraction wells at an average rate of 20 cubic feet per minute (cfm), and from bioventing wells at an average rate of 5 cfm, for a total average extraction rate of approx. 125 cfm and a maximum rate of 175 cfm.

2. Influent soil vapor will be treated by a catalytic oxidation unit. The estimated maximum concentration of total volatile organic compounds in the effluent air stream is 0.019 pounds per hour (assuming a 95% removal efficiency by catalytic oxidation).

3. All soil vapor extracted from the wells will be treated and discharged: influent volume is equivalent to effluent volume.

SVEFLOW.DWG

APPENDIX E
Preliminary Operations and Maintenance Plan

IEC
Independent
Equipment
Corporation

5 Johnson Drive, P.O. Box 130
Raritan, NJ 08869-0130
908 526-1001
FAX 908 526-7887

OPERATION AND MAINTENANCE MANUAL CONTAINER-MOUNTED SOIL VAPOR EXTRACTION AND GROUNDWATER TREATMENT SYSTEM

FOR

FORENSIC ENVIRONMENTAL SERVICES, INC.
623 North Pottstown Pike
Suite A
Exton, PA 19341

AT

ESSO TUTU GAS STATION
ST. THOMAS
U.S. VIRGIN ISLANDS

PREPARED BY

INDEPENDENT EQUIPMENT CORPORATION
P.O. Box 130
Raritan, New Jersey 08869-0130

IEC Project No. 315-88033-00-000

PRELIMINARY DRAFT

IEC

OPERATION AND MAINTENANCE MANUAL

CONTAINER-MOUNTED SOIL VAPOR EXTRACTION AND GROUNDWATER TREATMENT SYSTEM

IEC Project No. 315-88033-00-000

Owners
Consultant: **FORENSIC ENVIRONMENTAL SERVICES, INC. Exton, PA**

Owner: **ESSO, Virgin Islands, Inc., Cyril E. King Airport, St. Thomas, U. S. V. I.**

Supplier: **INDEPENDENT EQUIPMENT CORPORATION, Raritan, N. J.**

Job Site: **ESSO TUTU GAS STATION, St. Thomas, U. S. V. I.**

NOTE: The following pages provide a system description and general Operations & Maintenance (O & M) instructions. **The operator should read all sections of this manual carefully as each section provides specific O & M information for various system components.**

TABLE OF CONTENTS

DRAWINGS:

DRAWING NO.:	TITLE:
880XX-00-400	Trailer-Mounted Water Treatment System Layout
880XX-00-600	Process and Instrumentation Diagram
880XX-00-700	Electrical Service

SYSTEM COMPONENTS

TAB NO.	DESCRIPTION
1.	Control Panel, Control Logic and Wiring Diagrams
2.	Groundwater Extraction Pumps
3.	Coalescing Type Oil/Water Separator, Side Mounted Float Switch
4.	Centrifugal Pumps
5.	Blower
6.	Air Compressors
7.	Filter Housing & Bag Filters
8.	Totalizing Flow Meter
9.	Air Stripper
10.	Liquid Phase Granular Activated Carbon Vessels
11.	Pressure Gauge, Differential Pressure Switch
12.	Air Sparge Blower, Inlet Filters, and Accessories
13.	Regenerative Blower and Demister Skid
14.	Thermal/Catalytic Oxidizer
15.	PVC Piping & Hose, Quick Connectors, Hose Nipples
16.	Ball Valves, Check Valves, Bulk Head Fittings, Vacuum Relief Valve, Fittings, & Piping
17.	Load Center, Electrical Equipment, Lighting, Exhaust Fan
18.	Shipping Container, Door
19.	Soil Vapor Extraction Blower, Filters and Accessories
20.	Chemical Injection System Tank, Metering Pump, and Mixer

SYSTEM DESCRIPTION

General

This system is a combination Soil Vapor Extraction (SVE), Bioventing, and Groundwater Treatment System, designed to remove volatile and non-volatile organic compounds (principally petroleum hydrocarbons) from groundwater and soil. The treatment system itself is housed in one 40-foot long shipping container.

- **Soil Vapor Extraction System**

This Soil Vapor Extraction (SVE) System is designed to remove gasoline components from vadose zone soil. The soil vapor will be drawn from five (5) extraction wells at a combined total maximum total air flow rate of 175 cubic feet per minute (CFM) and a vacuum of 20 inches of water column ("w. c.). Each well has individual in-line flow meters, vacuum gauges, and flow control valves.

Soil vapor is passed through a 30-gallon moisture separator (KOD-101). Water collected in the moisture separator is pumped back into the oil water separator (OWS-101) using positive displacement pump (PDP-101). The air exiting the moisture separator passes through an in-line filter and then through a regenerative blower, where its temperature is increased, via compression, and then passed through the thermal/catalytic oxidizer (TCO-101) that destroys the contaminants.

The catalytic bed will eventually become "spent" and will require change out. A bed becomes spent when "break-through" occurs. Break-through is measured by an increase in volatile component concentrations leaving the stack. Manufacturer recommendations should be followed. The current system operators hold a copy of the owner's manual for the catalytic oxidizer. Sampling will be required to determine when breakthrough has taken place.

- **Bioventing Injection System**

The Bioventing Injection (BI) system is designed to supply ambient air to the vadose zone soil at a maximum total air flow rate of 35 CFM at an applied pressure of 20" w. c. The air is supplied by a regenerative blower (B-102) with inlet particulate filter (F-102). The air is distributed through a manifold that will be branched inside the container to provide a flow of 7 CFM to each of the five (5) proposed BI wells. Each well has individual in-line flow meters, pressure gauges, and flow control valves.

- **Bioventing Extraction System**

The Bioventing Extraction (BE) system is designed to withdraw air from the vadose zone soil at a maximum total air flow rate of 50 CFM at an applied vacuum of 20" w. c. The air is withdrawn by the same blower used for the SVE system. The air is collected through a manifold that will be branched inside the container to provide a flow of 5 CFM to each of the five (5) proposed BE wells. Each well has individual in-line flow meters, vacuum gauges, and flow control valves.

- **Groundwater Treatment System**

This system is designed to remove volatile and non-volatile organic compounds (principally petroleum hydrocarbons) from groundwater. The treatment system itself is housed in one container located at the job site. Fluids to be treated are drawn from recovery wells and piped back to the trailer through a series of subsurface piping. Treated water leaving the system is pumped into the storm sewer.

Total fluids are drawn from eight (8) extraction wells (RW-1 thru RW-8) installed by others at the job site. The maximum flow for each well is 2.5 gallons per minute (gpm). Fluids withdrawn from the wells by pneumatic submersible pumps (P-1 thru P-8) are pumped to the treatment system. Fluids from the wells, flow through individual flow meters (FM-103 through FM-110) to a coalescing type oil/water separator (OWS-101) & holding tank.

Free product, if present, floats to the top of the OWS tank and flows by gravity into a plastic 55-gallon recovered product tank (PRD-101). Normal flow of process water is by gravity flow from the OWS tank to a plastic 500-gallon transfer tank (T-101) and is pumped by transfer pump (P-101) through filter housing (BFH-101). Pressure gauges are located on the inlet and outlet of the filter housing, which allow the operator to determine the pressure drop across the filter bag.

An adjustable set point differential pressure switch (DPS-101) is connected across the inlet and outlet-piping manifold of the pre-filter. When the differential pressure or "delta p" across the on-line filter (BFH-101) reaches the set point of DPS-101 (15 psi), the alarm will sound, the system blower & well pumps will shut down, and the telephone dial-out system is activated to notify the operator of a system shutdown.

Water exiting the pre-filter flows to the top of a low profile, tray-type air stripper (LPAS-101). Water flows down through the air stripper by gravity. Ambient air is drawn through an inlet filter/silencer (AFS) and is forced upward (i.e. counterflow) across the trays. The trays provide a large surface area to allow a thin water layer to form. The water layer interacts with or is aerated by the upward airflow. As the air flows past the water, volatile organic compounds

(VOCs) transfer (hence, the term "mass transfer") from the water into the air. This process is commonly referred to as air stripping. The air at the outlet is vented to the atmosphere.

The water flows down into the stripper sump, that is fitted with three level switches, which control centrifugal pump (P-102). This transfer pump delivers the water to a second set of bag filter housings (BFH-102 & BFH-103).

The operation of the final filters is identical to that of the pre-filter as described above. DPS-102 provides an alarm and system shutdown when the pressure drop across the filter exceeds 15 psi. The function of the final filters is to remove finer particulate (mostly iron oxidized in the air stripper) from the water to lower the amount of solids loading at the top of the liquid phase granular activated carbon (GAC) bed (described below). Initially the filter bags will have a pore size of 10 microns for the final filters.

The final filters are equipped with vent and sample valves and pressure gauges as described above for the pre-filter. Water discharged from the final filter housings flows through a totalizing flow meter (TFM) and to the inlet header of the liquid phase granular activated carbon (GAC) adsorber vessels (GAC -101 & GAC-102). The GAC header contains a pressure relief valve (PRV) set at 15 psi to protect the lead GAC vessel from excessive pressure. Any water flowing through the PRV is piped back to the sump in the LPAS.

The liquid phase carbon adsorbers each contain 200 pounds of 8 x 30 mesh GAC. The function of the carbon adsorbers is to remove any residual VOCs from the water stream not removed by the air stripper. GAC treatment is a precautionary measure only. The air stripper will reduce BTX contamination to below discharge limits. The carbon adsorber vessels are connected for series operation (A to B or B to A). Vent and sample valves are provided on GAC adsorber vessels so that trapped air can be vented out of the system, and so that samples can be obtained for laboratory analyses. Pressure gauges are located on the inlets and outlets of the GAC adsorber vessels.

Water exiting the second GAC is discharged into the storm sewer.

- **Chemical Feed System**

This system is designed to prevent iron and manganese from precipitating out of the groundwater being treated and fouling the air stripper trays. The system consists of an 85-gallon chemical-mixing tank (MT-101) and mixer (M-101), and a metering pump (MP-101). A sequestering agent, in dry form, is placed into the 85-gallon tank and mixed with water to obtain a 1% solution. This solution is pumped to transfer tank (T-101) at a pre-determined rate.

- **Adsorption of VOCs by the Activated Carbon Vessels**

The GAC adsorbs volatile organic compounds from the liquid stream by forming a bond between the VOC molecules and adsorption "sites" in the micropore structure of the activated carbon. The carbon beds will continue to adsorb VOCs until an equilibrium condition is reached for the adsorption of each compound. The amount of each compound to be adsorbed per pound of carbon will vary from compound to compound, and will vary by the concentration of a given compound in the liquid stream.

The GAC beds will eventually become "spent" and will require periodic change out. A bed becomes spent when "break-through" occurs. Breakthrough is measured by an increase in VOC concentrations leaving the first stage (i.e. lead) GAC adsorber vessel. Regular sampling (using the sample valves provided) will be required to determine when break-through has taken place on the lead liquid phase GAC vessel.

This remediation system uses carbon vessels in series so that when break-through occurs in the first or "lead" bed, the second or "polish" bed continues to adsorb the volatile organic components. When required, the spent vessel is removed from the system. The previous polish bed (which is partially spent) is reconnected using flexible hoses to become the new lead bed. A fresh vessel is then connected as the new polish bed.

Spent vessels are shipped off site to a US EPA RCRA Part "B" approved treatment, storage, and disposal facility for reactivation of the spent GAC. Serviced vessels can then returned to the site for future use at the next change out cycle.

<u>NOTE:</u> Please refer to the Equipment Layout Plan and P&ID drawings at the end of this text section to follow the normal flow of air and water through the system. Also, please refer to control drawings in Section 1.

SEQUENCE OF OPERATIONS AND GENERAL O&M INSTRUCTIONS

- **Soil Vapor Extraction System**

Normal operation for the soil vapor extraction system is by automated control with regular operation and maintenance checks by the system operator. Extracted soil vapor is delivered from five (5) SVE wells, via a common manifold, to a 30-gallon moisture separator (KOD-101) and processed in a continuous mode. The piping from each SVE well is supplied with a flow control valve, an in-line air flow meter (AFM 102 through AFM 106), and a vacuum guage.

The moisture separator is equipped with three float switches. When the water level rises above the mid float switch, the transfer pump (PDP-101) turns on, pumping product and water from the moisture separator into the oil water separator (OW-101). If the transfer pump malfunctions and, the high float switch in the moisture separator will light the high level lamp, sound an alarm, and interrupt power to the regenerative blower (B-102 & B-103). The low float switch shuts off the transfer pump. An in-line air filter (F-101) is located downstream of the moisture separator and upstream of the regenerative blower. The in-line air filter is equipped with a differential pressure switch (DPS-104) to indicate the pressure drop across the filter element. A high differential pressure sounds an alarm and interrupts power to blower (VP-101) in the event of excessive pressure drop across the in-line filter.

The regenerative blower draws up to 175 CFM of air, 20 CFM from each SVE well and 5 cfm from each BE well at an applied vacuum of 20" w. c. at the wells. Inlet piping from the extraction wells and from a primary dilution air inlet are manifolded together. The dilution air inlet is installed with a vacuum relief valve and an inlet air filter (F-103). Dilution air will be drawn from the air stripper exhaust stream. Temperature, pressure, and vacuum indicators are installed upstream and downstream of the blower. An orifice plate type flow meter measures airflow at the discharge of the blower. A differential pressure switch to indicate the pressure in the line between the regenerative blower and the catalytic oxidizer is included. This line includes a pressure relief valve (PRF-102). A high differential pressure in this line sounds an alarm and interrupts power to the blower in the event of excessive pressure at the blower discharge.

Air exiting the blowers is passed through the thermal/catalytic oxidizer to destroy the volatile organic components that have been extracted from the soil.

- **Bioventing Injection System**

Normal operation for the Bioventing Injection (BI) system is by automated control with regular operation and maintenance checks by the system operator. Compressed air is delivered to a distribution manifold in a continuous mode.

The regenerative blower (B-102) draws 35 CFM of ambient air and delivers it at an applied pressure of 20" w. c. at the BI wells. Outlet piping to the BI wells is manifolded together. Temperature, pressure, and vacuum indicators [10] are installed upstream and downstream of the blower. An orifice plate type flow meter [8] measures airflow at the discharge of the blower. An inlet air filter [3] is located upstream of the blower. The air filter is equipped with a differential pressure gauge to indicate the pressure drop across the filter element. A high differential pressure switch [9] sounds an alarm and interrupts power to the blower in the event of excessive pressure drop across the inlet filter.

A differential pressure switch [9] to indicate the pressure in the line between the blower discharge and the distribution manifold is included. A high differential pressure in this line sounds an alarm and interrupts power to the blower in the event of excessive pressure at the blower discharge.

- **Bioventing Extraction System**

Normal operation for the Bioventing Extraction (BE) system is by automated control with regular operation and maintenance checks by the system operator. Compressed air is delivered to a distribution manifold in a continuous mode.

The same regenerative blower used for SVE will draw air from the soil at an applied vacuum of 20" w. c. at the BE wells. Piping from the BE wells is manifolded together inside the container. Temperature, pressure, and vacuum indicators [10] are installed upstream and downstream of the blower. An orifice plate type flow meter [8] measures airflow at the discharge of the blower. An in-line air filter [3] is located upstream of the blower. The air filter is equipped with a differential pressure gauge to indicate the pressure drop across the filter element. A high differential pressure switch [9] sounds an alarm and interrupts power to the blower in the event of excessive pressure drop across the in-line filter. Extracted air is treated by the catalytic oxidizer.

- **Groundwater Treatment System**

Normal operation for this groundwater treatment system is by automated control with regular operation and maintenance checks. Groundwater is extracted from eight (8) extraction wells each fitted with a pneumatic submersible well pump [P-1 thru P-8].

The pumps operate only when full with water.

Water flow from the wells can be monitored by individual flow meters (FM-103 thru FM-110), and can be adjusted with flow control valves on either side of the flow meters. Extracted groundwater is delivered to OWS and processed in a continuous mode. As water flows into the OWS, an equal amount of water is displaced by gravity flow out of the water outlet of the OWS to the transfer tank (T-101). The transfer tank is equipped with three float switches. When the water level rises above the mid float switch (LSH-101), centrifugal transfer pump (P-101) turns on, pumping water from the transfer tank into the pre-filter (BFH-101). The low float switch (LSL-101) shuts off the transfer pump. If activated, the high float switch (LSHH-101) in the transfer tank will light a high level lamp, sound an alarm, and interrupt power to the well pumps. *This alarm does not automatically reset, and requires the operator to depress the "RESET" push button on the control panel to restart the system.*

Any free-phase organic floating on top of the water in the OWS tank can be removed by opening manual decant valves and allowing the floating product layer (plus a small amount of water) to flow through a gravity drain hose into a 55-gallon recovered product tank [PRD-101]. The recovered product tank has a high-level float switch (LSHH-102). If activated, the high level switch sounds an alarm, lights a red lamp, and interrupts power to the system blower which in turn will prevent the well pumps from operating. *This alarm does not automatically reset, and requires the operator to depress the "RESET" push button on the control panel to restart the system.*

The water is pumped by the centrifugal pump (P-101) into the prefilter. At a point, when the filter bag is sufficiently dirt loaded to exhibit a 15 pound pressure differential, the alarm will sound, the system blower & well pumps will shut down, and the telephone dial-out system is activated to notify the operator of a system shutdown. This is a *manual* reset alarm.

The air stripper (LPAS-101) requires a total air flow of approximately 300 SCFM. Air is drawn from inside the container to provide a constant vent flow to control fugitive VOC in the room air and from the headspaces in the tanks.

A forced-draft blower (B-101) pushes air through the stripper. A differential air pressure gauge [DPG] is connected at the outlet of the air filter to indicate excessive pressure drop from dirt loading in the air filter. An air-proving switch [PSL-1] senses air pressure in the base of the stripper. When there is little or no air pressure at this point in the system, PSL-1 remains closed sending control power to an amber lamp on the panel. If there is sufficient flow (pressure) to close PSL-1, control power reaches PSL-2, located at the base of the outlet stack from the system. When there is little or no flow at the base of the stack, PSL-2 remains closed sending control power to the second amber lamp on the panel. If there is sufficient flow (pressure) to close PSL-2, then the control power reaches the "automatic" side of control power to the well pump controls. This allows the well pumps to operate in normal automatic mode. Thus, the operation of the well pumps (i.e., the flow of water through the system) is "permissive" on "proving" airflow through the system. When either amber lamp is on, the well pumps are disabled from operation in the "automatic" mode. The system is configured so that a portion of the air stripper off-gas can be re-directed to the inlet of the TCO.

Contaminated water flows down through the LPAS while clean air flows up through the stripper trays (i.e., counterflow operation). The resulting aeration causes a mass transfer of ~99+ % of the BTX components from the groundwater into the air moving through the stripper. The stripper sump is equipped with three float switches. When the water level rises above the mid float switch (LSH-103), the submersible pump (P-102) turns on, pumping water from the sump through either of the two (2) final filters (BFH-102 or BFH-103). The low float switch (LSL-103) shuts off the submersible pump. If activated, the high float switch (LSHH-103) in the sump will light a high level lamp, sound an alarm, and interrupt power to the well pumps. This is an *automatic reset* alarm.

The air stripper sump is equipped with a drain line that has a normally closed manual ball valve.

Water from pump P-102 is pumped into the final filters [BFH-102 & BFH-103]. The operation of the final filters is identical to that of the pre-filter as described above. DPS-102 provides an alarm and system shutdown when the pressure drop across the on line filter exceeds 15 psi. This is a *manual* reset alarm.

Water discharged from the final filter housings flows through a totalizing flow meter (TFM) and to the inlet header of the liquid phase granular activated carbon (GAC) adsorber vessels (GAC-101 & GAC-102). The GAC header contains a pressure relief valve (PRV) set at 15 psi to protect the GAC vessel from excessive pressure. Any water flowing through the PRV is piped back to the sump in the LPAS.

After treatment through the GAC vessels, process water flows into the storm sewer.

SYSTEM START-UP PROCEDURES

- Perform all of the visual checks listed in the Operations Checklist.
- Check that all of the "HAND-OFF-AUTO" switches are in the "AUTO" position.
- Check all valve positions.
- Check to ensure that all quick connect fittings are coupled.
- Power to the Control Panel should always be "ON". Check the white power "ON" lamp to verify that there is power to the Control Panel.

NORMAL SHUT-DOWN PROCEDURE

- Turn the "HAND-OFF-AUTO" switches for the pumps to the "OFF" position.
- Leave power to the Control Panel "ON". Check that the white lamp remains lit.
- Turn power off to the Control Panel.

EMERGENCY SHUT-DOWN PROCEDURE

- Place the main circuit breaker located in the Load Center to the "OFF" position.

OPERATION CHECKLIST

The following is a list of operation and maintenance checks for the system along with the approximate frequency that these checks should be performed. This is only an estimate of the required tasks; it does not take into account additional monitoring or testing required by permits or other regulatory requirements on the system. This list shall be amended as required during start up and operation by the licensed operator responsible for system operations and regulatory compliance.

WEEKLY:

- Turn on exhaust fan prior to entering process room.
- Check for alarm conditions or power failures.
- Check system for liquid and air leaks.
- Check pressure drop across bag filter housings.
- Check pressure drop across liquid-phase activated carbon beds. If the pressure drop is to high, there may be a blockage in the vessels or supply hoses. Typical maximum pressure drops across liquid phase GAC vessels is ~5 psi.
- Check operation of and readings on the water totalizing flow meter.
- Check level in recovered product tank. When required, remove recovered product and dispose of it as per state and local regulations.
- Check level in chemical feed tank. When required, add sequestering agent.
- Check for accumulated solids in the oil/water separator tanks. Drain system and remove solids if enough have accumulated to restrict water flow or affect OWS performance.
- Push "LAMP TEST" to check alarm lamps for burned-out bulbs. Replace pilot lamps if required.
- Collect a water sample from between the first and second liquid-phase GAC vessels for laboratory analysis per permit requirements to determine if breakthrough has occurred.

HEALTH & SAFETY

GENERAL

The following Health and Safety protocols are presented here for information and as a suppliment to the site specific Health and Safety Plan. IEC is not responsible for the omission of H&S information. Groundwater treatment plant personnel are subject to physical and bodily injury as are workers in all industries. However, the groundwater treatment industry has a high potential for accidents caused by the presence of noxious gases and chemicals. Therefore, anyone engaged in the operation of a groundwater treatment plant should be familiar with safety practices that pertain specifically to his/her profession. Where indicated, the Occupational Safety and Health Administration (OSHA) require the following safety recommendations. Other generally accepted safety recommendations are also included, and these are covered in more detail in Safety in Groundwater Works, Water Pollution Control Federation publication (Manual of Practice No. 1).

In 1971, the Occupational Safety and Health Act (OSHA) became law. A more thorough analysis of the safety and health standards covered by this Act may be found in the Federal Register, Volume 36, No. 105, Part II (May 29, 1971).

The procedures and practices established herein address frequently encountered problems and normal plant operating procedures. However, such procedures and practices are not intended to serve as a substitute for common sense or for safety practices and procedures recommended by equipment and material vendors and suppliers. Because of the unusual and unforeseeable conditions and circumstances that may arise from the operation of this plant, this manual cannot and does not represent a comprehensive set of guidelines for such unusual or unforeseen conditions or circumstances. The Site Specific Health and Safety plan must be followed.

Overall Safety Program

The development of a safety program is a necessity for any utility, particularly groundwater treatment plants. The purpose of the program is to define the principles under which the work within the plant is to be accomplished, to make the employees aware of safe working procedures, and to recommend specific regulations and procedures.

Safety Committee

One of the most effective methods of establishing and maintaining a safety program is the appointment of a safety committee composed of maintenance personnel and management. The purpose of this committee is to create an interest in safety among the workers at the Groundwater Treatment Facility and to emphasize the employee's responsibility for the prevention of accidents.

The functions of the safety committee will include:

- Education of personnel.
- Stimulation of interest in safety.
- Periodic safety inspections.
- Reporting unsafe conditions and/or practices.
- Investigation of accidents.
- Coordination of injury reports.
- Development and distribution of safety precautions, warnings, and other safety documents.
- Recommendations for improvements in the safety program.
- Development of safety standards.
- Documentation of compliance with and enforcement of OSHA standards.
- Evaluation of safety suggestions.

Safety Education and Training

The most essential element of a good safety program is the incorporation of a well-conceived safety training plan. The purpose of safety training is to bring the importance of safety to the plant employees. Safety training can be accomplished through the use of manuals, meetings, or posters placed in strategic areas in the plant, and a safety suggestion program.

The establishment of a safety suggestion program is an especially valuable means of acquiring safety training since it not only provides a means of securing many worthwhile ideas for effective safety practices, but also encourages the plant employees to think about safety.

RESPONSIBILITY

Safety is everybody's responsibility. Injuries must be avoided if the treatment facility is to operate at peak efficiency. Injuries are an indication that equipment, procedures, or employee training are inadequate. Therefore, everyone associated with the operation of the plant must share the responsibility for determining and implementing safe working procedures.

Management Responsibility

If injuries are to be prevented, initial action must begin at the management level. Management must exercise leadership in safety as it does in all the other phases of work.

Management determines many of the factors contributing to the occurrence or prevention of an accident.

Management provides the place to work. If the place is hazardous, personal injuries are more likely to occur.

Management provides and maintains the work facilities. If unsafe or inadequate tools, equipment, layout, and materials are provided or if tools, equipment, layout, surroundings, etc., are not maintained in a safe condition, personal injuries are more likely to occur.

Management selects, hires, and places the workers. If the workers selected are physically and mentally unable to do the work required or do not possess the necessary aptitudes for specific tasks, personal injuries are more likely to occur.

Assuming that management has complied with the above criteria, and the worker is trained, capable, and working in a safe place with good tools, vehicles, and equipment, the worker is responsible for his/her safety.

Supervisor's Responsibility

The supervisory personnel of the Groundwater Treatment Plant have a key responsibility for safety within the plant. The supervisor of operations has direct control of the work performed by the operators and other workers in the plant (part-time maintenance men, etc). The supervisor is responsible for setting work patterns and implementing a safety program. This can be accomplished by instructing employees on safe working habits and by reviewing their work for compliance with established safety regulations. The supervisor should also conduct monthly safety inspections of the facilities and equipment throughout the treatment facility.

Employee's Responsibility

Workers have a responsibility to themselves, their families, and their jobs to do everything they can to prevent personal injuries. This can be accomplished by conformance to established safety regulations and by use of proper safety equipment in the performance of the daily work routine. Human error is the most significant cause of accidents, and it is the employee's responsibility to perform his/her job safely.

EMERGENCY TELEPHONE NUMBERS

The following is a list of local emergency telephone numbers. This list should be posted at all telephone locations. See the Site Specific Health and Safety Plan for important telephone numbers.

Hospital (Public Hospital)
Fire and Rescue
Police

DEFINITION OF HAZARDS AND HAZARDOUS AREAS

Whether in the room with the process treatment units, or inside the control room, the overall danger of accidents is the same. These hazards can usually be classified under one of the following categories:

- Physical injuries.
- Dangers from noxious gases or vapors and/or from oxygen deficiency.

Physical injuries can be defined as any type of cuts, bruises, sprains, broken bones, bums, or infections. Physical injuries can occur in manholes, pumping stations, confined spaces, or treatment plants through handling objects, falling objects, falls, stepping on or striking objects, machinery, or heat (fire, steam, etc.). Physical injuries are usually caused by some action, lack of action, failure to practice accepted safe procedures, or unsafe mechanical or physical conditions. All physical injuries should be treated promptly by qualified personnel.

In the operation of groundwater works, the greatest hazard from noxious gases and vapors and/or oxygen deficiency will be found in the following areas:

- Deep sewer manholes.
- Enclosed groundwater rooms.
- Underground structures, such as covered empty tanks of all descriptions, pipe galleries, or check valve pits where an oxygen deficiency may occur.
- Vessel containing activated carbon.

In some cases, these hazards are inherent in the design of the plant or specific equipment items. Once they are recognized, they can be readily corrected, or at least guarded by proper warnings and safety procedures.

ELECTRICAL HAZARDS

Since most of the mechanical equipment in the treatment facility is powered by electricity, the following rules should be adhered to:

- Do not ground yourself in (come in direct contact with) water, on pipes, or drains.
- Avoid such areas when working near any electricity.
- Allow only authorized people to work on electrical equipment and repairs.
- Keep all electrical controls accessible and well marked.

- Keep rubber mats on the floor in front of electrical panels; keep edges trimmed so that they do not become a tripping hazard.
- Keep wires from becoming a tripping hazard.
- Work in pairs around electrical equipment.
- Lock out the switches when working on electrical equipment which another person might inadvertently turn ON.
- Never use metal ladders around electrical equipment.
- Handle breakers wires as though they were "live" wires.
- When there is a question about any electrical hazard, ask before you expose yourself to it.
- Do not use any part of your body to test a circuit. Ground all electrical tools.
- When working around electrical equipment, as with any other hazardous work, keep your mind on the hazard at all times.

MECHANICAL EQUIPMENT HAZARDS

The following general safety regulations outline most of the safety precautions applicable to work around mechanical equipment.

- No one should be allowed at this treatment facility while under the influence of intoxicating beverages or substances.
- No one should be allowed to work while his/her abilities are impaired by fatigue, illness, or other causes that might make him/her susceptible to accidents or injury.
- Horse-play of any sort will not be tolerated.
- Employees will not work in or around any mechanical equipment lacking belt guards or other protective devices.
- Workers will perform no maintenance beyond the scope of their duties, unless first receiving specific instructions from their supervisor.
- No employee will enter any underground structure unless the appropriate safety procedures are followed.
- All personnel will thoroughly cleanse that portion of their body that inadvertently comes in contact with a poisonous or infectious substance.
- Employees will familiarize themselves with the location and operation of all fire extinguishers and safety equipment.
- Hard hats will be worn at all times where there are low-hanging objects in the work area or where danger of falling objects exists.
- Goggles or glasses with eye shields must be worn in areas with potential eye hazards (i.e., chemical handling area).
- Loose clothing, dangling ties, etc. should not be worn around any moving mechanical equipment.
- No mechanical equipment will be repaired or adjusted while in operation.
- Gasoline or other highly-flammable liquids should not be used for cleaning purposes.

- All injuries or accidents should be reported immediately to the plant supervisor. Injured personnel requiring a physician may not return to work without that physician's release.
- All areas within this treatment facility will be **kept clean and free from safety hazards.**

EXPLOSIONS AND FIRE HAZARDS

Fires are always a danger, but groundwater treatment facilities present special problems due to their chemical hazards. All plant personnel should be trained in the proper use of all fire extinguishers and in the correct procedure for turning in fire alarms. Highly visible signs should mark the location of each extinguisher and fire alarm. All fire extinguishers should be hydrostatically tested by reputable testing companies every year or as specified by the manufacturer.

2.7.1 Fire Classes

Fires are classified into the following four classes:

A. Combustible materials (paper, wood, carbon, rags, and some plastics, etc.).
B. Flammable liquids (gasoline, kerosene, solvents, etc.).
C. Energized electrical circuits.
D. Hazardous materials (phosphorous, magnesium, etc.).

Class A fires of combustible materials are best controlled with water. A 2 1/2-gallon pressurized water extinguisher filled with an antifreeze solution is the best kind for this type of fire. These extinguishers should be checked monthly by reading the pressure gauge mounted at the top of the unit. If the gauge reads 'in the operating range, the unit is ready for action. Should the unit become discharged, notify your supervisor. 2-A rating is the minimum recommended size for each extinguisher.

Class B fires are those involving liquid petroleum including methane, propane, natural gas, gasoline, and other fuel oils. Some plastics also fall into this category and produce toxic gases as a byproduct of combustion. On small fires, extinguishers, which use dry chemicals or carbon dioxide, are effective.

Fire departments may use water on larger fires of this type; however, this should never be done by anyone other than fire department personnel. Normally, these fires should be fought with dry chemical or carbon dioxide fire extinguishers.

Dry chemical extinguishers come in a variety of sizes ranging from 2 1/2pounds up through 20-pound models. There are two basic types of dry chemical apparatus: B-C types and A-B-C types. The B-C types are effective against A, B, and C classes of fires. These extinguishers are filled with chemicals which are ground into fine particles. Breathing these particles may be fatal. These chemicals are also very corrosive and should be removed as soon as possible after use. These units come with pressure gauges, which indicate whether or not they are operational, and should be checked monthly.

Carbon dioxide extinguishers are rated for B and C class fires and leave no residue after use. On each extinguisher near the valve assembly, a weight (in pounds) is stamped. This is the full weight and should be checked monthly. These extinguishers are well suited for chemical labs where dry chemical extinguishers may contaminate chemicals.

Class C fires are those involving energized electrical circuits. These can be controlled with carbon dioxide as described previously.

Class D fires are fueled by burning metals such as phosphorus, magnesium, sodium, etc., and are controlled by special powders which smother the fire

Fire Prevention Regulations

The following fire prevention regulations should be adhered to:

- All work areas will be kept clean and free from accumulations of trash and debris.
- Rags containing grease and oil should be deposited only in a vented metal container.
- All potential fire hazards should be reported immediately to a supervisor.
- Extreme care should be exhibited whenever handling flammable liquids.

Fire Procedures

Any report of fire or smoke should be promptly reported to the fire department. When turning in a fire alarm, be sure to give as much information as possible, including: exact location, street or road, type of fire, your name, telephone number, number of people injured, etc. Remain on the phone until the fire department tells you to hang up. Generally, the following procedures should be implemented:

- Evacuate all personnel from the danger zone.
- Notify the fire department and supervisor reporting the location, type, and extent of the fire. Request medical-assistance for injured personnel.
- If the fire is electrical, de-energize the circuit and call the electrician.
- Identify the type of fire and use all available means to combat it.

HEALTH HAZARDS

Physical injuries can lead to health hazards. The following actions should be considered when physical injuries occur:

- All cuts, skin abrasions, and similar injuries should be treated promptly. In addition, all cuts and scratches, no matter how small, should be treated immediately with a disinfectant.
- Medical help should be obtained for all but minor injuries.
- Treatment plant personnel should be familiar with first aid treatment.
- Avoid putting fingers in the nose, mouth, or eyes while working.
- Thoroughly clean hands when convenient and always before eating or leaving work. Fingernails should be kept short to aid cleanliness.

CHEMICAL HANDLING HAZARDS

The minimum safety regulations required for development of an effective accident prevention program in the chemical handling are as follows. Plant operators are encouraged to supplement this list as required to maintain safe working conditions.

Chemical Handling Area Conduct

- Follow instructions explicitly.
- Perform only authorized procedures,
- Protect eyes, face, hands, and body.
- Practice good housekeeping.
- Learn basic first aid.
- Know where to get help fast.
- Know location of first aid and fire-fighting equipment.
- Report at once to your supervisor all accidents and unusual occurrences.
- Do not smoke while performing laboratory and chemical handling tests.
- Do not "horse around." It's dangerous!
- Ensure that exits, aisles, stairways, doors, etc. are clear at all times.
- Use exhaust hoods.
- Endure that ventilators are working.
- Work in adequate lighting.
- Do not clutter the chemical handling area with unneeded or unused furniture.
- Maintain adequate storage facilities.

CHEMICAL HANDLING

The minimum safety regulations required to effectively prevent chemical accidents are as follows. Plant operators are encouraged to supplement this list as required to maintain safe working conditions. It should be noted, however, that regulations are of little value unless supervisory personnel ensure compliance.

- Immediately remove all chemical spills by flushing the area with water or desorbing with an inert absorbent material.
- Whenever working around chemicals, all personnel must wear the proper safety equipment.
- All personnel must learn the location and use of safety equipment, hose bibs, and first aid kits prior to working in either the chemical building or storage area.
- All operating personnel at this treatment facility should be thoroughly familiar with the appropriate first aid procedures in case of accidental chemical contamination. These procedures should be obtained from each chemical supplier prior to receiving the initial shipment. It should be remembered that first-aid is intended to serve only as an interim treatment until qualified medical help can be summoned.

OPERATIONS & MAINTENANCE

Any equipment-specific O & M will be supplied by vendor upon receipt of equipment. General O & M procedures will be incorporated into the O & M activities and checklists.

APPENDIX F
Health and Safety Contingency Plan

HEALTH & SAFETY CONTINGENCY PLAN

Esso Tutu Service Station
St. Thomas, U.S.V.I.

August 14, 1998

Prepared by:

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1.0 INTRODUCTION

1.1 Introduction

The Forensic Environmental Services, Inc. (FES) Health and Safety Contingency Plan (HSCP) described herein presents health and safety procedures and emergency response guidelines to be implemented during the Unilateral Administrative Order (UAO) supplemental investigation and the remedial system installation/Source Control Program for the Esso Tutu Service Station. Activities will also be performed on the adjacent Four Winds Plaza property which bounds the Esso Tutu Service Station to the north, west, and south (Splash-n-Dash Car Wash). The site is located in Anna's Retreat, on the island of St. Thomas in the U.S.V.I. Site location and site layout maps are presented in Figures 1 and 2, respectively.

Site activities will be coordinated and implemented by FES and subcontractors. FES personnel will be on site to conduct field operations, and oversee the collection of supplemental RD data as well as install, test and operate the Source Control Program. Health and safety measures described herein are designed to protect FES personnel from site environmental hazards. This program has specifically been developed to address health and safety issues pertaining to FES personnel. Information presented in the HSCP should be reviewed by other site personnel prior to individual subcontractors developing their own Health and Safety Plan. On-site personnel and subcontractors other than FES are required to prepare and are responsible for administration of their own health and safety program.

1.2 Proposed On-Site Investigations

The scope of work associated with the Source Control Program is presented in FES's "Remedial Design Investigation/Source Control Program", dated June 1997. Specific elements of the Source Control Program and supplemental UAO investigation include the following:

1. The installation of ground-water monitoring and extraction wells;
2. The installation, and sampling of soil borings;
3. The installation of soil vapor extraction (SVE) and bioventing wells;
4. Ground-water sampling;
5. Trenching activities associated with the installation of the soil and ground-water remedial systems; and
6. Soil sampling to characterize drill cuttings and soils excavated as part of the trenching activities.

During field activities, there is the potential for FES personnel to come in contact with soils, ground water, and/or wastes potentially containing hazardous constituents. This HSCP has been developed with the following goals in mind:

1. FES on-site personnel are not adversely exposed to chemicals of concern.
2. FES personnel are in compliance with all applicable state, federal, and non-governmental regulations. The rules and guidelines set forth in the Occupational Safety and Health Act (OSHA) Part 1910 (Title 29 Code of Federal Regulations CFR Part 1910.120) will be implemented for all site activities.

Due to the nature of project tasks, all field work activities that potentially involve contact with hazardous materials will be considered "Contaminated Operations" requiring varying degrees of personal protective equipment (PPE). A description of the required PPE is presented in Section 4.0.

This HSCP applies specifically to FES personal on site during the UAO investigation, Source Control Program and all related activities. All field activities conducted by FES personnel will be performed in accordance with the provisions set forth in this HSCP.

2.0 SITE INFORMATION

The Esso Tutu Service Station is located adjacent to the Four Winds Plaza on Smith Bay Road (Route 38), south of the intersection with Route 384 (Figure 1). The station presently operates as a gasoline retail facility, but in the past also conducted vehicle maintenance and repair activities. Gasoline at the station is presently stored in two on-site underground storage tanks (USTs) located in the southeastern corner of the property (Figure 2). Gasoline is dispensed to vehicles from the pump island located approximately 50 feet north of the USTs.

The Esso Tutu service Station building is located in the central portion of the site and is used for the storage of station records and retail products (one-quart oil cans, windshield fluid, etc.). Also within the building are vacant rooms which had previously served as vehicle maintenance bays prior to termination of repair activities.

Former structures at the site include an enclosed garage/storage area, open garage areas, and a garage enclosed by a steel cage (Figure 2). These former structures have been demolished in preparation for installation of the remedial system.

The former enclosed garage/storage area (located in the southern portion of the site) was previously used for the storage of supplies and equipment related to site environmental studies. Materials previously contained within this area included a ground-water treatment system, health and safety equipment, and sampling tools.

The former open garages (including the caged garage) were located in the southwestern corner of the site (Figure 2). The open garage areas had previously served as vehicle repair bays and/or storage areas. Within these areas are two former subsurface oil/water separators, designated as the "south oil/water separator" and the "north oil/water separator" (Figure 2). Historically, it has been reported that the north oil/water separator was utilized as a "holding tank", receiving used motor oil generated in the service bays. The south oil/water separator received both used motor oil and storm water generated in the service bays previously located along the southern and western boundaries of the site. The south oil/water separator was cleaned of its contents in November 1993 and subsequently filled with concrete. Although not filled with concrete, the north separator has been emptied of its contents and cleaned.

Previous site investigations have determined that soil and ground-water quality have been impacted. The exposure routes, threshold limit values (TLV's), and IDLH concentrations set forth by OSHA, NIOSH, and the AICGH for certain constituents identified as being present on and adjacent to the subject site are presented in Table 1.

3.0 EMPLOYEE TRAINING AND TESTING

3.1 Employee Training

All site workers involved in hazardous or potentially hazardous work will have met the requirements set forth in 29 CFR 1910.120 (e). These requirements include forty hours of off-site classroom training in hazardous waste site safety, three days of on-site field experience working under a trained, experienced supervisor, eight hours of annual refresher training, and eight hours of supervisor training for employees in supervisory positions. All personnel will be required to provide documentation on the successful completion of the training requirements of 29 CFR 1910.120.

In addition, a health and safety site indoctrination session will be presented by FES prior to commencement of site activities. This session will include a review of planned work activities, known or suspected contaminants present, potential health and safety hazards, health and safety protection procedures including PPE and equipment, and the site emergence response plan.

3.2 Medical Surveillance

All FES personnel who may be exposed to hazardous substances or health hazards on-site will participate in a medical surveillance program that meets the requirements set forth in 29 CFR 1910.120 (f). These requirements specify that employees who satisfy one of the following conditions receive a medical examination at least annually:

1. engage in site operations in which they have the potential to be exposed to hazardous substances at or above the permissible exposure limits (PEL), or published exposure levels, for more than 30 days a year;

2. wear a respirator for more than 30 days a year; or

3. are injured due to overexposure involving a hazardous substance.

Additionally, employees who wear respirators must be determined to be fit to perform their work duties while wearing a respirator.

There are no site-specific medical surveillance requirements for this project. Medical examinations must be conducted by or under the direct supervision of a licensed physician. Medical records for all FES personnel are maintained in the firm's Exton, Pennsylvania office. These medical records detail the tests that were conducted and include a copy of the participating physician's written opinions and recommended limitations for the employee.

4.0 PERSONAL PROTECTIVE EQUIPMENT

4.1 Personal Protective Equipment

This section of the HSCP describes the requirements for PPE and the levels of protection required for each individual work task. All site personnel are required to use PPE that is appropriate to the health and safety hazards to which they may be exposed. Basic PPE in all site areas consists of a hard hat, safety glasses, and steel-toed boots. PPE requirements will vary depending on the work task and the employee's location at the site.

All personnel on site will wear PPE when activities involve the potential for exposure to contaminated vapors, gases, or particulate, or when direct contact with a contaminated substance may occur. Chemical resistant clothing will prevent contaminants from absorbing into the skin. Respirators will protect the lungs and gastrointestinal tract. Full-face respirators will also provide eye protection. Respiratory protection levels will comply with air monitoring results collected by FES personnel, as discussed later in this HSCP.

The specific protection levels for each work task is listed in Table 2. All field activities will require the use of one of the following levels of PPE:

Level C

1. Full-face, air-purifying, canister equipped respirator with organic vapor and particulate cartridges.
2. Chemical resistant clothing (overalls and long sleeved, hooded jacket); one or two piece chemical splash suit; or disposable, chemical resistant one piece suit.
3. Inner and outer chemical resistant gloves.
4. Steel-toed boots with chemical resistant covers.
5. Hearing protection as needed.

6. Hard hat.
7. Two-way radio communication.

Modified Level D

1. Tyvec coveralls or poly-coated tyvec coveralls.
2. Steel-toed boots.
3. Disposable, chemical resistant inner gloves.
4. Outer, chemical resistant work gloves.
5. Safety glasses.
6. Splash shield, if necessary.
7. Hearing protection, if necessary.
8. Hard hat.

Level D

1. Standard work uniform or coveralls.
2. Steel-toed work boots.
3. Gloves if necessary.
4. Safety glasses.
5. Splash shield if necessary.
6. Hearing protection if necessary.
7. Hard hat.

Miscellaneous PPE

1. Knife.
2. Flashlight or lantern.
3. Personal dosimeter (volatile organic compounds and particulates)

PPE will be stored in a designated area on-site and will be maintained in a clean sanitary condition and ready for use. All PPE will be inspected before each use to ensure that all equipment is functioning properly and is free from defects. Any coveralls which have been torn/ripped will be disposed of once the employee has left the work zone. Hard hats and respirators will be thoroughly cleaned after each use and respirator cartridges will be discarded daily.

4.2 Limitations of Protective Clothing

PPE ensembles designated for use during field activities have been selected, and will be selected, to provide protection against contaminants at known or anticipated concentrations in the soil. However, no protective garment, glove or boot is chemical proof, nor will it afford protection against all chemical materials. In order to obtain optimum usage from PPE, the following procedures will be developed:

1. Inspect all boots, gloves, and clothing prior to entering the Exclusion Zone (EZ) for rips, tears, poorly functioning closings, etc.; and
2. Inspect all reusable garments for visible signs of chemical penetration, discoloration, cracks, punctures, and abrasions;

4.3 Respiratory Protection Program

All FES personnel will have received the proper training in the use of air purifying respirators, and have been fit tested for full-face respirators. All employees will be in compliance with the rules and guidelines set forth in 29 CFR 1910.134. To assure worker protection from airborne particulate and volatile organic compounds (VOC's), air purifying respirators will be used based on air monitoring results conducted by FES personnel.

A photoionization detector (PID) will be used to determine if organic vapors are present in the worker breathing zone. Background readings for the PID will be taken prior to commencement of work activities. Air monitoring results will be used to determine action levels and dictate levels of PPE to be used based upon the known contaminants in the work area. The action levels and necessary respiratory protection for all activities are as follows:

Sustained Organic Vapor Reading Above Background Within Working Breathing Zone	Action Levels
Background	Full-face respirator available
>Background - 2.5 ppm	Wear full-face respirator
>2.5 ppm	Wear supplied air (positive pressure) respirator
>500 ppm	Shut down activities, vacate area

The appropriate air-purifying respirator cartridge will be used to provide protection for organic vapors. The respirator and respirator cartridge must be from the same manufacturer.

4.4 Site Control

Vehicular and public access to the Esso Tutu Service Station is from the east via Route 38 during normal business hours typically from 7 a.m. to 11 p.m. The open garage areas in the southwestern area of the site are enclosed by a retaining wall and chain restricting public access. Access to the Four Winds Plaza property and the Splash-n-Dash Car Wash is also from Route 38.

Designated work areas on both the Esso Tutu Service Station and Four Winds Plaza properties will be established by FES personnel to facilitate completion of field activities. The purpose of establishing work areas will be to limit access to potentially contaminated areas, and to prevent the migration of potentially hazardous materials from the areas of impact. Specific work areas to be defined at the site include:

Exclusion Zone (EZ): The EZ is the area immediately surrounding the active work area, with boundaries modified depending on operational requirements. Sufficient area will be provided within the EZ to allow efficient movement of personnel and equipment. The EZ will be defined by the FES HSO. All personnel entering the EZ will be required to wear the appropriate PPE.

Contaminant Reduction Zone (CRZ): The CRZ will be utilized as the location for removal of contaminated PPE and final removal and decontamination of personnel and equipment. Supplementary safety equipment, such as fire extinguishers, potable eyewash and extra quantities of PPE may be stored in this area. Safety equipment will be donned in the following order: 1) tyvek suit, 2) rubber boot, 3) gloves, 4) respirator, and 5) hard hat. Safety equipment will be removed according to the following protocol:

1. wash off boots and outer gloves prior to removal;
2. tyvek suit;
3. hard hat;
4. respirator; and
5. inner gloves.

Support Zone (SZ): The SZ will be located in a non-impacted area where the threat of exposure to hazardous materials is minimal. As such, PPE other than standard construction clothing and equipment is not required.

5.0 AIR MONITORING

5.1 Monitoring Program

Periodic monitoring of particulate levels and organic vapors will be conducted throughout field activities by FES personnel. Particulate monitoring will only be conducted during activities which may potentially lead to contaminant excursion from the site (e.g. soil excavation (trenching activities), stockpiling, and handling).

The following instruments will be used for air monitoring during field activities:

1. Photoionization detector (PID)
2. Particulate monitor

All monitoring equipment will be calibrated daily according to the manufacturer's specifications. The date and time of instrument calibration will be logged in the field book as well as the periodic monitoring results.

All air monitoring will be conducted in the breathing zone of the workers on an hourly basis or as deemed necessary by the site HSO. Background measurements on all instruments will be taken at an area upwind of the work area to establish baseline levels before activities commence. Work activities generating particulate levels greater than 150 $\mu g/m^3$ (15 minute average) or organic vapor levels greater than 1 ppm above background at the downwind perimeter of the EZ will temporarily be halted until levels drop to acceptable levels.

6.0 DECONTAMINATION PROCEDURES

All personnel, protective equipment, and equipment entering the site must be decontaminated or properly disposed (as appropriate) upon exit from the EZ. In addition, all personnel must enter and exit the EZ through the decontamination area, defined by the FES HSO. Prior to demobilization, potentially contaminated PPE and equipment will be decontaminated and inspected by the FES personnel before it is moved into the clean zone. Any material that is generated by decontamination procedures will be stored in a designated area in the EZ until disposal arrangements are made. The decontamination solution for the equipment and PPE at the Esso Tutu Service Station is Alconox.

6.1 Equipment Decontamination

All equipment which enters the EZ will subsequently be decontaminated in the CRZ by a pressure wash cleaner. Decontamination procedures will include: removal of soil/mud by scraping or knocking; rinse using a solution of water and Alconox; and rinse by potable water. Decontamination of equipment will occur on the wash pad constructed in the CRZ so that rinsates and solids can be collected for subsequent disposal. Decontamination of equipment will be performed in Level C PPE.

6.2 Personnel Decontamination Procedures

FES personnel will utilize the following procedure when exiting the EZ:

Station 1: Equipment Drop

Deposit equipment used in the EZ on plastic drop clothes. All equipment utilized in the EZ will be decontaminated or discarded as waste prior to removal from the EZ. Equipment shall be defined as any sampling tool or device, monitoring device, radio, etc.

Station 2: Outer Boot and Outer Glove Wash and Rinse

Scrub outer boots, outer gloves and/or splash suit with decontamination solution or detergent wash. Rinse off using water.

Station 3: Outer Boot and Outer Glove Removal

Remove outer boots and gloves. Disposable boots and gloves will be deposited in a designated covered container and ultimately disposed. Boots and gloves which are not considered disposable will be stored in clean dry location.

Station 4: Outer Garment Removal

Remove outer garments and deposit in a covered container. Decontaminate or dispose of splash suits as necessary.

Station 5: Respiratory Protection Removal

Remove hard hat and facepiece, and deposit on a clean surface. Air purifying respirator cartridges will be discarded as appropriate. Wash and rinse respirator at least daily. Wipe off and store respiratory gear in a clean, dry location.

Station 6: Inner Glove Removal

Remove inner gloves and place in a covered container.

Station 7: Field Wash

Thoroughly wash face and hands using a soap and water solution.

7.0 GENERAL SAFETY AND PERSONAL HYGIENE

7.1 Heat Related Disorders

Due to the physical nature of the work tasks, in conjunction with the elevated temperatures and humidity levels in the Virgin Islands, heat related illnesses are a significant health and safety concern. Several factors influence a person's susceptibility to heat related disorders including a person's physical condition, level of acclimatization, age, and gender. The four most common heat related disorders are from least to most serious are listed below:

> **Heat Rash:** The most common heat rash is known as prickly heat, which appears as red bumps. It usually occurs in areas where clothing is restrictive. It occurs around skin that is kept wet by unevaporated sweat. Rash areas can become easily infected if not treated and allowed to dry.
>
> **Heat Cramps:** These are not uncommon in individuals who work hard in the heat. They are attributable to a continued loss of salt, accompanied by large intakes of water without appropriate replacement of electrolytes. Cramps often occur in the muscles principally used during work and can be treated by rest, ingestion of water, and an electrolyte solution.
>
> **Heat Exhaustion:** The symptoms of heat exhaustion include fatigue, weakness, headache, vomiting, fainting, and dilated pupils. Other symptoms of heat exhaustion which are **not** seen in heat stroke (discussed below) are: pale, clammy skin, profuse sweating, and a normal body temperature. Treatment includes removing the victim from the hot area, applying cool cloths to the skin, loosening or removing clothing, and providing water and an electrolyte solution.
>
> **Heat Stroke:** Heat stroke is the most serious of the heat related illnesses. Symptoms of heat stroke include dizziness, confusion, collapse, delirium, constricted pupils, and coma. Other symptoms of heat stroke which are **not** seen in heat exhaustion (discussed above) are hot, dry skin, elevated core temperature, red skin. If symptoms of heat stroke are evident, remove the victim from the hot area and seek medical attention.

Because the incidence of heat stress depends on a variety of factors, a workers heart rate and oral temperature will be monitored on a regular basis during the work day. Oral temperatures will be taken with an oral thermometer. Base-line temperature and heart rate readings will be taken prior to the commencement of work activities each day, and at designated intervals throughout the day. Heat stress monitoring will be performed by the site HSO, and work/rest intervals will be designated as appropriate.

Heart Rate: If the heart rate exceeds 110 beats per minute at the beginning of the rest period, the next work cycle will be shortened by one-third without changing the rest period. If the heart rate still exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one-third.

Oral Temperature: If the oral temperature exceeds 99.6°, shorten the next work cycle by one-third without changing the rest period. If the oral temperature still exceeds 99.6° at the beginning of the next rest period, shorten the following work cycle by one-third.

7.2 General Safety Protocols

In addition to those measures identified above, FES personnel will abide by general safety protocols outlined at the site. These protocols may include:

1. Designation of Eating Areas: Eating at the site is prohibited except in specifically designated areas. Designation of eating areas will be the responsibility of the FES HSO. The location of these areas may change during the project to maintain adequate separation from the work area.

2. Designation of Smoking Areas: Smoking at the site is prohibited except in specifically designated areas to be identified by the FES HSO.

3. Individuals getting wet to the skin with effluent from the washing operation must wash the affected area immediately. In addition, if clothes which are in contact with skin become wet then these garments must be changed.

4. Hands must be washed with a soap solution before eating, drinking, smoking, and before using toilets at the site.

5. All disposable coveralls and soiled gloves will be disposed of in a designated plastic bag at the end of every shift or sooner.

8.0 CONTINGENCY PLANNING AND EMERGENCY RESPONSE

8.1 Emergency Numbers and Contacts

Emergency Contacts

Fire	911
Police	340-774-2211
Ambulance	911
Hospital	Governor Roy L. Schneider Hospital 9048 Sugar Estate Charlotte Amalie, St. Thomas, U.S.V.I. Telephone: (340) 776-8311
Poison Control Center:	911

Directions to Hospital:

From Esso Tutu Service Station turn right onto Route 38. Continue to the intersection of Route 38 and Route 313 and turn right. The St. Thomas hospital is a large bright blue building on the right hand side. The distance from the subject work site to the hospital is approximately 4 miles, with driving time estimated to require 5 to 10 minutes. A hospital route map is presented in Figure 3.

Additional Emergency Numbers

Virgin Islands Territorial Emergency Management Agency (VITEMA)	340-774-2244
Department of Planning and Natural Resources (DPNR)	340-777-4577

FES Exton Office	610-594-3940
Site Telephone (Esso Tutu Service Station)	340-775-6609
Esso Terminal	340-774-6044

8.2 Medical Emergencies

Any person who becomes ill or injured in the EZ must be decontaminated to maximum extent possible prior to removal from the work area. If the injury or illness is minor, full decontamination of the injured person should be performed. If the injury is serious, decontamination should proceed to the extent possible without risking furthering injury to the subject person. All injuries will be reported to the FES HSO and documented in the FES HSCP field book.

Any person transporting an injured person to the hospital for treatment will take with them a copy of the FES HSCP. Any vehicle utilized to transport injured personnel to the hospital will subsequently be decontaminated as warranted.

9.0 RECORD KEEPING

9.1 Records

FES's HSO (Bryan J. Machella) will maintain records of all necessary and pertinent monitoring activities as described below:

- description of each work task completed on site;
- name and position title of employees involved on each specific work task;
- names of individuals working in the EZ; and
- emergency report sheets describing any incidents or accidents.

All records will be maintained in a project field book dedicated for the Fed Labs site.

TABLES

Table 1
Exposure Pathways and Exposure Levels
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Contaminant	Exposure Pathway	Acceptable Exposure Limits		IDLH
		NIOSH	OSHA	Concentration (OSHA)
Volatile Organic Compounds				
Benzene	INH, ING, ABS, CON	0.1 ppm	1 ppm	500 ppm
2-Butanone	INH, ING, CON	200 ppm	200 ppm	3,000 ppm
1,1 Dichloroethane	INH, ING, CON	100 ppm	100 ppm	3,000 ppm
1,2 Dichloroethene	INH, ING, CON	200 ppm	200 ppm	1,000 ppm
Ethylbenzene	INH, ING, CON	100 ppm	100 ppm	800 ppm
MTBE	NA	NA	NA	NA
Tetrachloroethene	INH, ING, ABS, CON	NA	100 ppm	150 ppm
Toluene	INH, ING, ABS, CON	100 ppm	200 ppm	500 ppm
1,1,1 Trichloroethane	INH, ING, CON	350 ppm	350 ppm	700 ppm
Trichloroethene	INH, ING, ABS, CON	NA	100 ppm	1000 ppm
Xylenes	INH, ING, ABS, CON	100 ppm	100 ppm	900 ppm
Base Neutral Compounds				
2-Methylnaphthalene	NA	NA	NA	NA
Acenaphthene	NA	NA	NA	NA
Anthracene	NA	NA	NA	NA
Benzo (a) Anthracene	NA	NA	NA	NA
Benzo (a) pyrene	NA	NA	NA	NA
Benzo (b) fluoranthrene	NA	NA	NA	NA
Benzo (b) fluoranthrene	NA	NA	NA	NA
Benzo (ghi) perylene	NA	NA	NA	NA
Bis (2-ethylhexyl) Phthalate	NA	NA	NA	NA
Butylbenzylphthalate	NA	NA	NA	NA
Chrysene	NA	NA	NA	NA
1,2 Dichlorobenzene	INH, IMG, ABS, CON	50 ppm	50 ppm	200 ppm
Di-n-Butylphthalate	NA	NA	NA	NA
Di-n-octyl Phthalate	NA	NA	NA	NA
Fluoranthracene	NA	NA	NA	NA
Fluoranthrene	NA	NA	NA	NA
Fluorene	NA	NA	NA	NA
Naphthalene	INH, ING, ABS, CON	10 ppm	10 ppm	250 ppm
Phenathrene	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA
Metals				
Lead	INH, ING, CON	0.100 mg/m^3	0.050 mg/m^3	100 mg/m^3
Total Petroleum Hydrocarbons				
Gasoline Range	INH, ING, ABS, CON	NA	NA	NA
Diesel Range	NA	NA	NA	NA

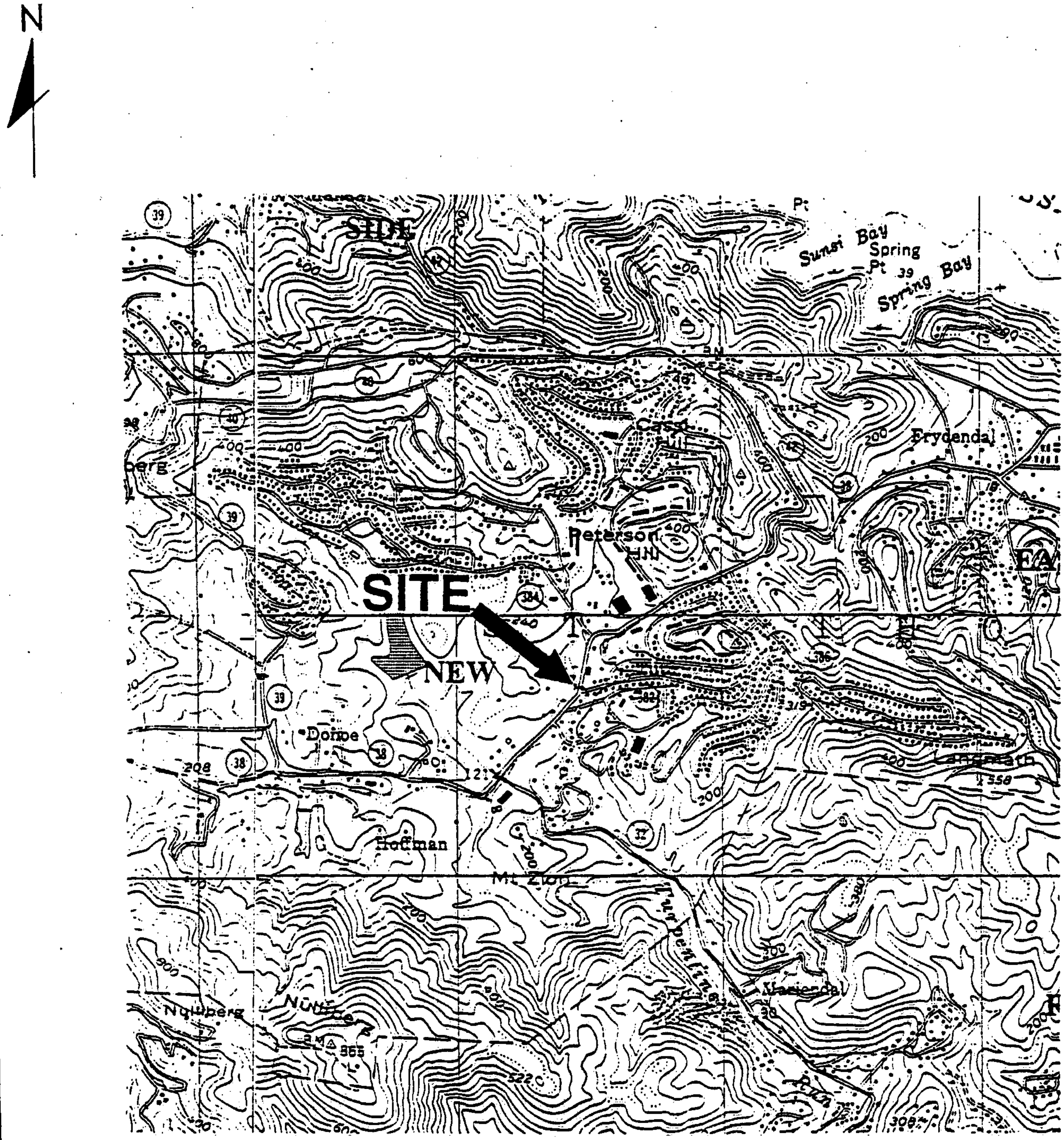
Notes:
1. Acceptable Exposure levels and IDLH concentrations were obtained from the NIOSH Pocket Guide to Chemical Hazards, June 1994
2. ppm = Parts Per Million
3. INH = Inhalation
4. ING = Ingestion
5. ABS = Absorption
6. CON = Contact
7. NA = Not Available

Table 2
PPE Requirements per Work Task
Esso Tutu Service Station
St. Thomas, U.S.V.I.

Work Task	Maximum Protection Level	Alternate Protection Level
Mobilization and Demobilization	Level D	Level D
Well Installation Activities (Ground-Water Monitoring & Extraction, SVE, and Bioventing)	Level D or Level C* based on air monitoring results	Level D
Soil Boring Installation and Soil Sampling	Level D or Level C* based on air monitoring results	Level D
Groundwater Sampling Activities	Level D or Level C* based on air monitoring results	Level D
Soil Excavation Activities (Trenching)	Level D or Level C* based on air monitoring results	Level D
Waste Characterization Soil Sampling Activities	Level D or Level C* based on air monitoring results	Level D

Notes:
1. Specific requirements for PPE are discussed in the HASP.
2. Alternate protection levels may be used if monitoring levels indicate that conditions are appropriate.
3. * = Level C: to be worn when the criterion for using air-purifying respirators are met and a lesser level of skin protection is needed. Level D: to be worn when no respiratory hazards are present.

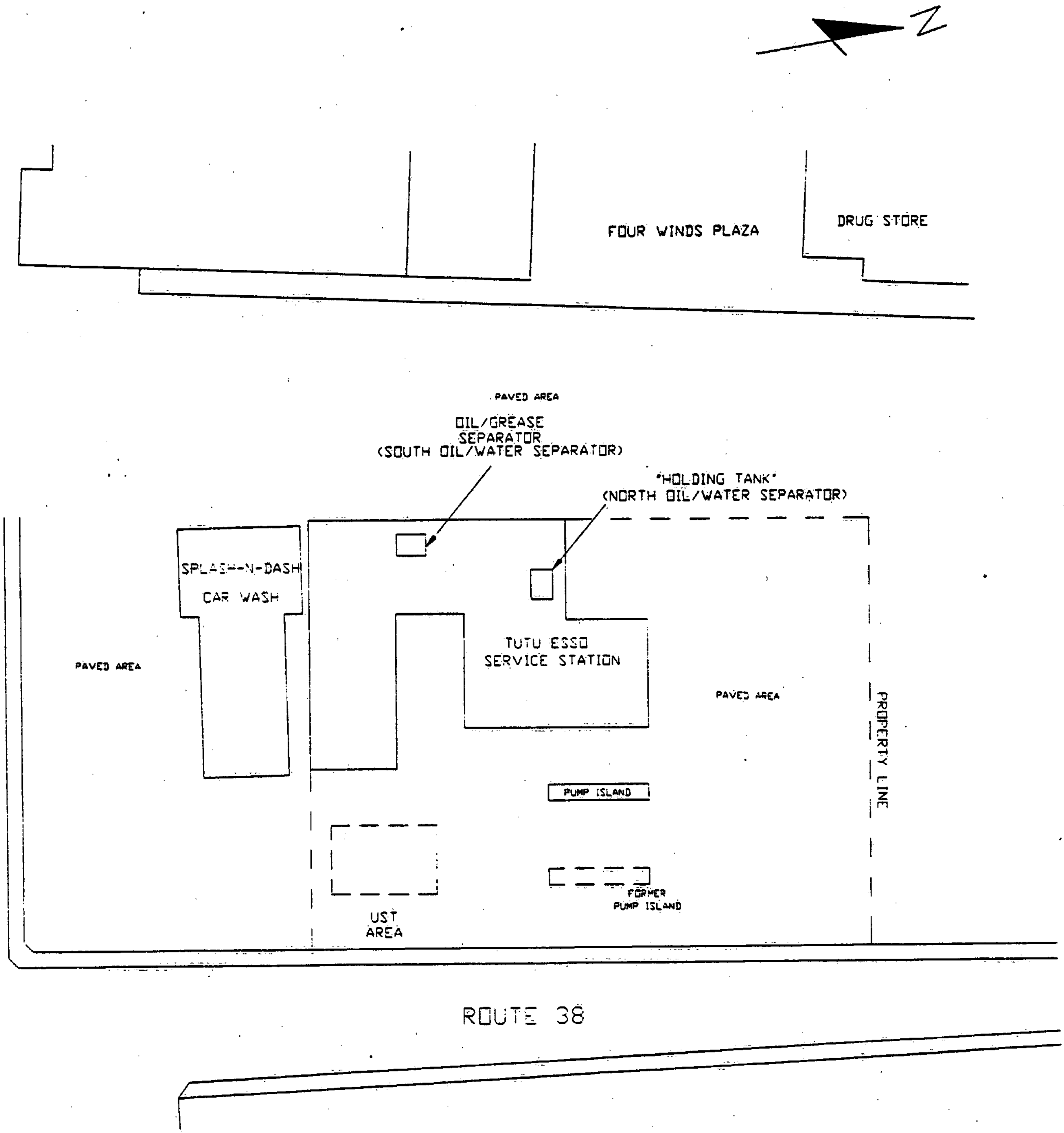
FIGURES



DERIVED FROM THE EASTERN AND CENTRAL ST. THOMAS V.I. 7.5 MINUTE QUADRANGLES COMPILED BY THE U.S. GEOLOGICAL SURVEY (PHOTO REVISED IN 1982).

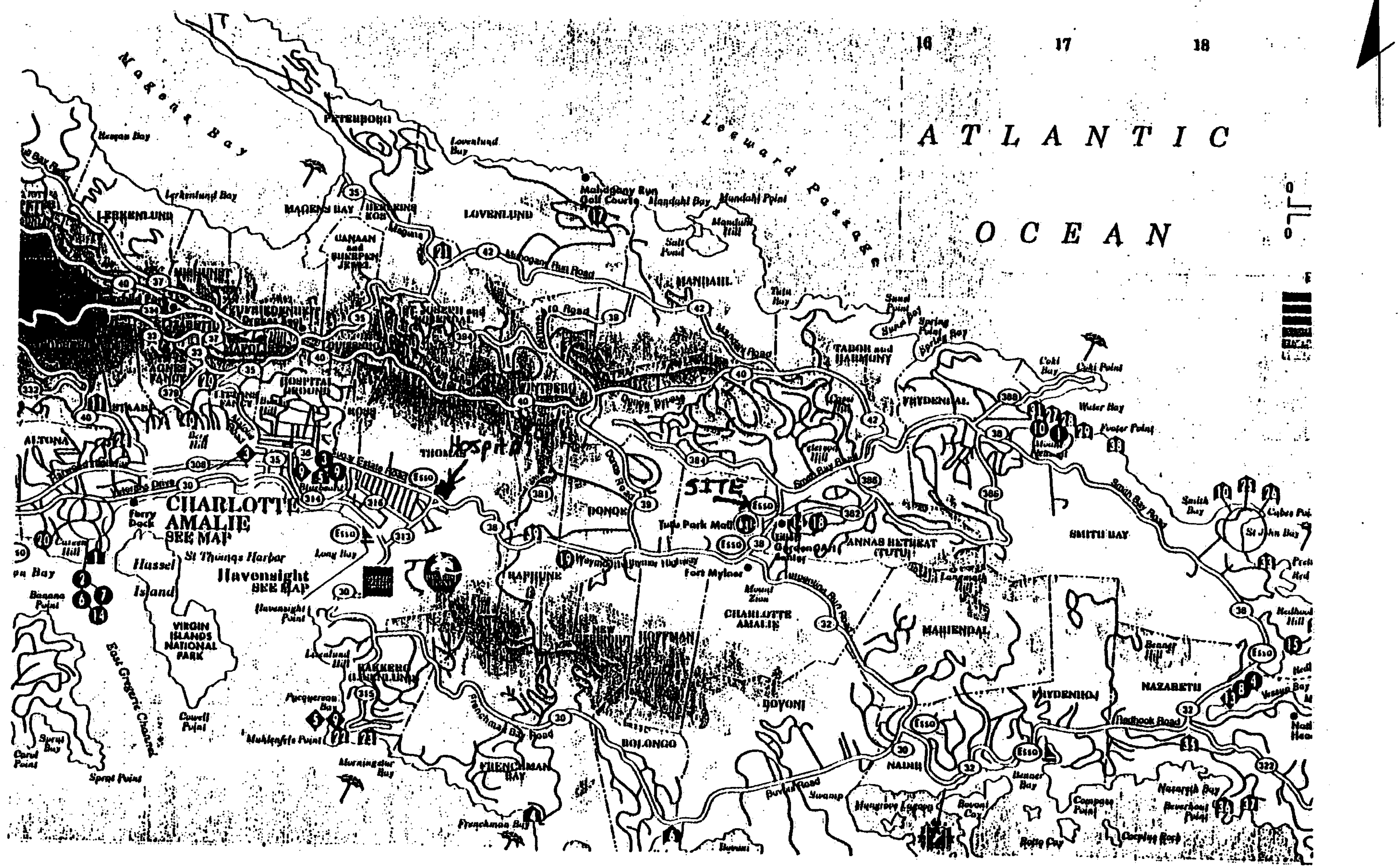
FORENSIC ENVIRONMENTAL SERVICES, INC.	FIGURE 1
SITE LOCATION MAP ESSO TUTU SERVICE STATION ST. THOMAS, U.S.V.I.	
0 2,000 SCALE IN FEET	DRAWN BY: B.J.M. 11/20/96 APPROVED BY:

TUTUTOPO.DWG



FORENSIC ENVIRONMENTAL SERVICES, INC.	FIGURE 2
SITE LAYOUT MAP ESSO TUTU SERVICE STATION ST. THOMAS, U.S.V.I.	
0 50 SCALE IN FEET	DRAWN BY: B.J.M. 9/11/96 APPROVED BY:

TUTUSITE.DWG



FORENSIC ENVIRONMENTAL SERVICES, INC.

FIGURE 3

ROUTE TO ST. THOMAS HOSPITAL
ESSO TUTU SERVICE STATION
ST. THOMAS, U.S.V.I.

APPENDIX G
Access Agreements